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RESCUING AN ELEPHANT CALF FROM A PITFALL.

By Parker Gillmore.

Before firearms were introduced into the interior of tropical South Africa, the greater part of the ivory exported from that country was obtained from elephants captured in pitfalls, in the construction of which the natives displayed great ingenuity. This talent was the result of their intimate knowledge of the habits of all wild animals that frequented the neighborhood in which they resided. As our youths go to school to fit themselves for their future avocations of life, so the Kaffir, Zulu or Bechuana youngsters go out on the veldt to study practical natural history, that they may become mighty hunters; for, when distinguished in this science, they are rapidly promoted to the rank of warriors, and then they have a voice in the councils of their respective tribes, and are permitted to marry, with other equally substantial advantages.

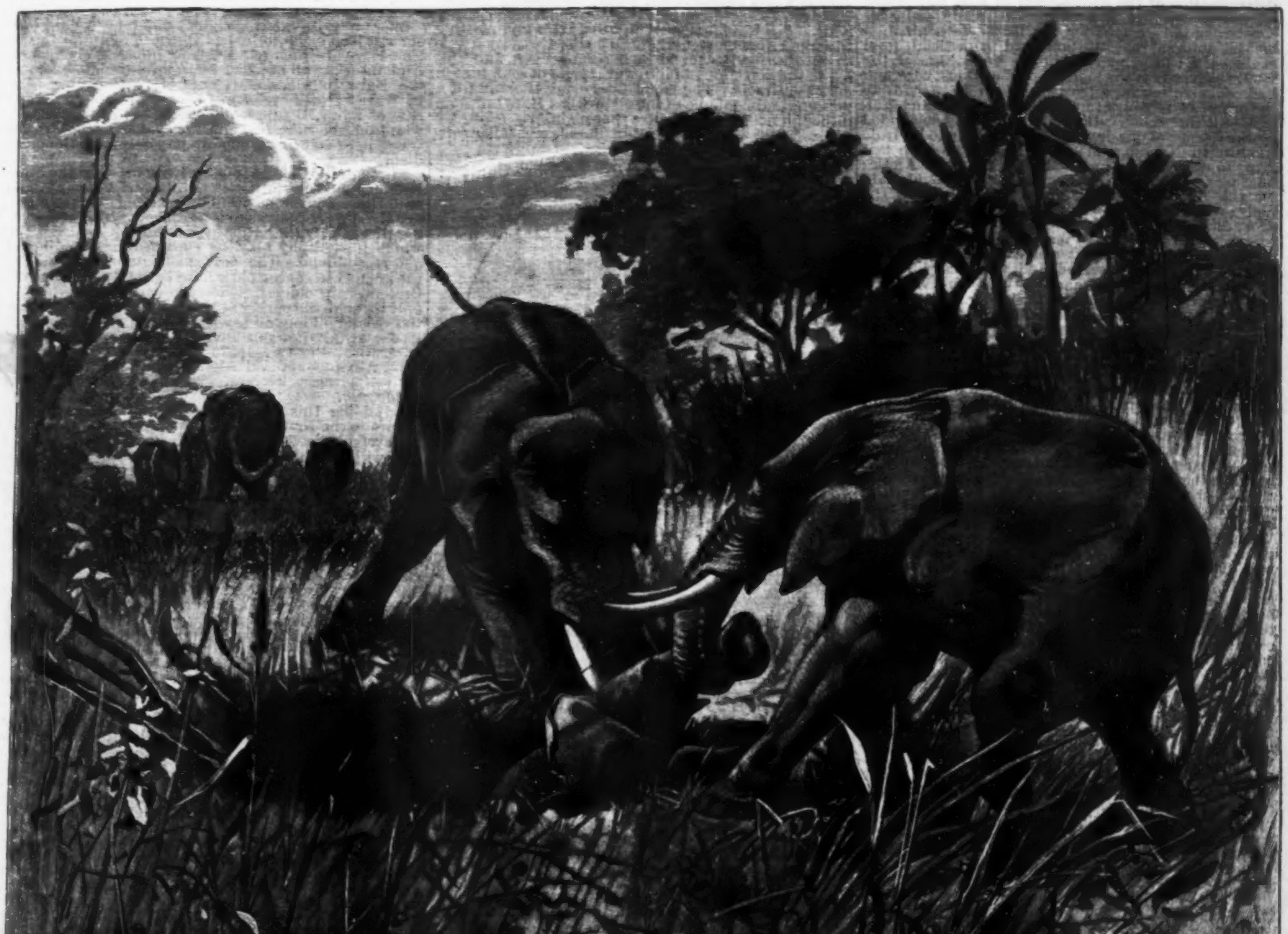
The pitfall that is constructed for the capture of elephants is a hole about ten or twelve feet long, five feet wide, and about ten or twelve feet deep. It is in shape from the surface of the ground to the bottom exactly like the letter V. This formation is adopted so that the unfortunate captive can obtain no footing for his large feet at the bottom; otherwise he would be able to rear on end and regain his liberty. For the companions of a mature old bull to lift him out of his perilous position would be a difficult task, but in the case of a half-grown youngst r the matter is comparatively simple. One of the herd entwines her trunk with the prisoner's, while another places her* proboscis under the captive's forequarters, when, with a strong heave and a heave together, liberation is rapidly accomplished.

The most difficult part of pit making is covering it over so that its upper surface exactly resembles the adjoining ground, otherwise the wary animals would take alarm and change their route, or go round them. To accomplish this, a layer of the slimmest canes are placed over the mouth of the pit; this, in turn, is covered with coarse veldt grass, the whole being top-dressed with sand, in which various common weeds or shrubs are planted. This labor being satisfactorily performed, the whole surface of the trap is abundantly watered, so that no taint of human presence can be detected, for the sense of smell is developed to an extraordinary degree in these mammoth beasts. Paths that elephants select when going to water, or the vicinity of favorable fruit trees—such as the meruleys—are generally the places selected for the position of the pitfall.

It is currently said among the native hunters that if once an elephant has escaped from one of these traps, no skill or artifice will ever induce it to enter another. This is not improbably true, for it is well known that they possess wonderful memories, and that after the lapse of years they will at once recognize a person who has treated them with cruelty or even unkindness. A young elephant that I possessed was burnt on the trunk by a Kaffir blacksmith. Many months afterward I returned to the neighborhood where this wanton act was performed to have some repairs done to my wagons. My pet followed me to the forge. I found the same man employed in his trade. While explaining my wants to him the youngster gave him a blow with his trunk that sent the man reeling for several yards.

The scene depicted in the sketch was witnessed by a Griqua who hunted for me. After listening to the "boy's" story, I visited the pitfall, and from close, practical examination of the place I am convinced that my informant had in no way exaggerated what he had seen.

If the chief of a country in which you are hunting is friendly to you, he will order all the pitfalls to be opened. When this has not been attended to, serious accidents have frequently happened to sportsmen.—*London Graphic.*



FEMALE ELEPHANTS RESCUING A YOUNGSTER FROM A PITFALL.

* The young are always with the females, who have only short tusks.

ANTARCTIC EXPLORATION.

At a recent meeting of the Royal Geographical Society, London, Dr. John Murray, of the Challenger expedition, read a paper on "The Renewal of Antarctic Exploration."

The meeting was really the initiation of a movement for the purpose of inducing government to aid in the equipment of an Antarctic expedition.

Dr. Murray, after sketching the history of Antarctic explorations and of the notions which prevailed as to the nature of the South Polar region from the earliest time down to the present day, showed that,

while the immense southern continent of past ages has been vastly diminished by increased knowledge, the probability is that around the South Pole there is a land area of about 4,000,000 square miles. The actual state of our knowledge of the region, he said, was extremely meager, and until that knowledge was greatly increased there were many problems in science that must remain unsolved. Until we had a complete and continued series of observations in the Antarctic area the meteorology of the globe could not be understood. Important problems in geology, in biology, in physics, in oceanography, demanded the renewal of research on an adequate scale in the South Polar area. As had been the case in the past, the solution of these problems by scientific investigation could not but have important practical results for humanity. Within the past few months he had been in communication with geographers and scientific men in many parts of the world, and there was complete unanimity as to the desirability, nay, necessity, for South Polar exploration, and wonder was expressed that an expedition had not long since been fitted out to undertake investigations which, it was admitted on all sides, would be of the greatest value in the progress of so many branches of natural knowledge. To determine the nature and extent of the Antarctic continent; to penetrate into the interior; to ascertain the depth and nature of the ice cap; to observe the character of the underlying rocks and their fossils; to take magnetical and meteorological observations both at sea and on land; to observe the temperature of the ocean at all depths and seasons of the year; to take pendulum observations on land, and possibly also at great depths in the ocean; to bore through the deposits on the floor of the ocean at certain points to ascertain the condition of the deeper layers; to sound, trawl, and dredge, and study the character and distribution of marine organisms—all this should be the work of a modern Antarctic expedition. For the more definite determination of the distribution of land and water on our planet; for the solution of many problems concerning the ice age; for the better determination of the internal constitution and superficial form of the earth; for a more complete knowledge of the laws which govern the motions of the atmosphere and hydrosphere; for more trustworthy indications as to the origin of terrestrial and marine plants and animals—all these observations were earnestly demanded by the science of our day. A few months ago he bade good-by to Nansen, and said he expected within two years to welcome him on his return from the Arctic; but he expressed some doubt whether he should again see the Fram. "I think you are wrong," was the reply; "I believe you will welcome me on this very deck, and after my return from the Arctic, I will go to the South Pole, and then my life's work will be finished." (Cheers.) That was a spirit we must all admire. We felt it deserved, and was most likely to command, success. All honor to those who ventured into the far north or south with slender resources and brought back with them a burden of new observations. A dash at the South Pole was not what he now advocated, nor did he believe that was what British science at the present time desired. It demanded rather a steady, continuous, laborious, and systematic exploration of the whole southern region with all the appliances of modern investigators. This exploration should be undertaken by the Royal Navy. (Cheers.) Two ships not exceeding 1,000 tons should, it seemed to him, be fitted out for a whole commission, so as to extend over three summers and two winters. Early in the first season a wintering party of about ten men should be landed somewhere to the south of Cape Horn, probably about Bismarck Strait, at Graham's Land. The expedition should then proceed to Victoria Land, where a second similar party should winter, probably in Macmurdo Bay, near Mount Erebus. The ships should not be frozen in, but should return to the north, conducting observations of various kinds toward the outer margins of the ice. After the needful rest and outfit, the position of the ice and the temperature of the ocean should be observed in the early spring, and later the wintering parties should be communicated with, and, if necessary, re-enforced with men and supplies for another winter. During the second winter the deep sea observations should be continued to the north, and in the third season the wintering parties should be picked up, and the expedition return to England. The wintering parties might largely be composed of civilians, and one or two civilians might be attached to each ship; this plan worked admirably during the Challenger expedition. What, it might be asked, would be the advantages to trade and commerce of such an expedition? It must be confessed that no definite or very encouraging answer could be given. We knew of no extensive fisheries in these regions. For a long time seal and sea elephant fisheries had been carried on about the islands of the Southern Ocean, but we had no indication of large herds or rookeries within the Antarctic Circle. A whale fishery was at one time carried on in the neighborhood of Kerguelen, but this right whale, if distinct from *Balæna Australis*, appeared to have become nearly if not quite extinct. Some expressions of Ross would lead one to suppose that a whale corresponding to the Greenland right whale inhabited the seas within the Antarctic ice, but we had no definite knowledge of the existence of such a species. Although whales, like the finner, were undoubtedly abundant, they did not repay capture, and though penguins exist in countless numbers, they were at present of no commercial value. Deposits of guano were not likely to be of any great extent, but it was impossible to speak with confidence on a matter like this—the unexpected might quite well happen in the way of discovery. With great confidence, however, it might be stated that the results of a well-organized expedition would be of capital importance to British science. We were often told how much more foreign governments did for science than our own. It was asserted that we were being outstripped by foreigners in the cultivation of almost all departments of scientific work. But in the practical study of all that concerned the ocean this was certainly not the case; we had to acknowledge no superiors, nor even equals, in this branch of investigation, and if we were a wise and progressive people, British science would always lead the way in this direction. This country had frequently sent forth expeditions, the primary object of which was the acquisition of new knowledge—such were the expeditions of Cook, Ross, and the Challenger; and the nation as a whole had always approved such action, and had been proud of the results, although they yielded no immediate return. (Cheers.) Should it be said that there was to be no successor to these great expeditions? The prestige of the navy did not alone consist in its powers of defense and attack. It had in times of peace made glorious conquests over the powers of nature, and it was asked that the officers and men of the present generation should be afforded the same opportunities as their predecessors. (Cheers.) A preliminary responsibility rested on the geographers and representatives of science in this country. It was necessary to show that we had clear ideas as to what was wanted, that a good workable scheme could be drawn up. When this had been done, it should be presented to the government with the unanimous voice of all our scientific corporations. He had little doubt that a minister would then be found sufficiently alive to the spirit of the times and with sufficent courage to add a few thousand pounds to the navy vote for three successive years, in order to carry through an undertaking worthy of the maritime position and the scientific reputation of this great empire. (Cheers.)

[Continued from SUPPLEMENT, No. 939, page 15006.]

THE MOON'S FACE—A STUDY OF THE ORIGIN OF ITS FEATURES.

By G. K. GILBERT.

Sculpture.—The rims of certain craters are traversed by grooves or furrows, which arrest attention as exceptions to the general configuration. In the same neighborhood such furrows exhibit parallelism of direction. Similar furrows appear on tracts between craters, and are there associated with ridges of the same trend, some of which seem to have been added to the surface. Elsewhere groups of hills have oval forms with smooth contours and parallel axes, closely resembling the glacial deposits known as drumlins, but on a much larger scale. Tracing out these sculptured areas and platting the trend lines on a chart of the moon, I was soon able to recognize a system in their arrangement, and this led to the detection of fainter evidences of sculpture in yet other tracts. The trend lines converge toward a point near the middle of the plain called Mare Imbrium although none of them enter that plain.

Associated with the sculpture lines is a peculiar soft-

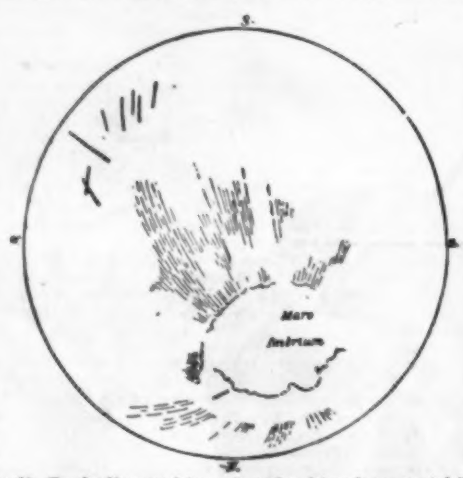


FIG. 14.—Trends of lunar sculpture. General sculpture is represented by shading; great furrows by heavy lines. Irregular lines show crests of uplands surrounding M. Imbrium.

ening of the minute surface configuration, as though a layer of semi-liquid matter had been overspread, and such I believe to be the fact; the deposit has obliterated the smaller craters and partially filled some of the larger. These and allied facts, taken together, indicate that a collision of exceptional importance occurred in the Mare Imbrium, and that one of its results was the violent dispersion in all directions of a deluge of material—solid, pasty, and liquid. Toward the southwest the deluge reached nearly the crater Theophilus, a distance of 900 or 1,000 miles, and southward it extended nearly to the latitude of Thebit. Northward and northeastward it probably extended to the limb. Westward it passed beyond Posidonius, and toward the east and southeast its traces are lost in the Oceanus Procellarum.

Its more liquid portion gathered on the lowlands, giving rise to several maria and minor plains. The fact has been recognized by various students, notably by Green * and Meydenbauer,† that many of the lunar plains are due to floods of molten material overspreading the low-lying tracts and burying the pre-existent irregularities of surface. At various points in such plains, and especially at their margins, crescentic hills project above them, recognized as portions of crater rims; and elsewhere the plains are divided by systems of cracks whose arrangement betrays the distribution of underlying ridges. The plains most closely associated with the sculpture system and the supposed viscous deposit are the Sinus Roris, Mare Frigoris, Lacus Mortis, Lacus Somniorum, Palus Nebularum, Mare Tranquilitatis, Mare Vaporum, Sinus Medii, Sinus Estuum, and Mare Nubium. The Oceanus Procellarum may have been created at the same time or may have been merely modified by this flood. The Mare Serenitatis, whose sharp outlines and circular form mark it as an old crater, doubtless received a new surface.

As to the precise nature of this catastrophe I am in doubt. Its focus lies within the great crater rim of the Caucasus, Apennine, and Carpathian ranges, but is not concentric with that rim, and it is not surrounded by a rim of its own. The lofty plateau lying north of the Mare Imbrium, although presenting a steep face toward the mare and a long slope in the opposite direction, has not the simple contour of a crater wall, but is variously notched. By considering the extent and probable thickness of the various deposits from the flood, it has been estimated that its volume may have equaled a sphere 80 or 100 miles in diameter, and there is perhaps no occasion for surprise that the results of the collision of a body of such magnitude were exceptional in character as well as extent.

* E. N. Green: Jour. Brit. Ast. Ass., April, 1891, p. 379.

† A. Meydenbauer: Sirius, February, 1882.

So far as I am aware, these features of sculpture have not previously been recognized.* It is therefore of special importance that my observations be verified by those of others, and to this end the general statement will be supplemented by the enumeration of enough particulars to serve as a clew to the recognition of the novel phenomena. The general distribution of the sculpture, comprising the districts in which it is faintly exhibited as well as those in which it is conspicuous, is indicated in Fig. 14, where the shaded areas represent sculpture districts and the direction of the fine parallel lines indicates the trend of the sculpture. The interspaces between shaded areas are largely occupied by maria and other plains on which no sculpture appears.

The boldest carving is seen on the Apennines, the crest line of which is cut into battlements. From the hollows between battlements, rude grooves follow radially down the southern slope to its base. A similar sculpture appears on the Caucasus, but the range is traversed obliquely, from E. S. E. to W. N. W. The sculpture features of the Carpathians are less conspicuous, but immediately south of them is a tract occupied by drumlin-like hills, the axes of which point toward the Imbrian plain. The broad isthmus between the Mare Vaporum and the Mare Serenitatis is so thoroughly sculptured that most of its features exhibit parallel trend in a southwesterly direction. The great crater of Julius Cæsar has lost most of its southern wall, and its valley is filled to the level of the remnant of rim on that side. Boscovich is barely to be recognized as a crater, and whatever other craters may have antedated the flood are defaced beyond recognition. Manilius, Menelaus, and a few others are of more recent date, and their clean-cut features stand in striking contrast to the general ruin.

Similar features with slightly different trend characterize the plain for 200 miles south of Julius Cæsar. The rims of Hipparchus, Albategnius, Ptolemy, and Alphonsus are all notched by grooves trending toward the Mare Imbrium, and some of these grooves can be traced to the vicinity of the crater Lalande. The rims of Parry, Bonpland, and Guerike, jutting islandwise from the Mare Nubium, are similarly notched, the trend here coinciding almost precisely with the meridian.

Through the entire region lying between the Mare Nubium and the Maria Serenitatis and Tranquilitatis sculpture and the associated veneering have so modified the surface that there is no difficulty in discriminating the craters of later date from those of earlier. The whole topography may be classified as antediluvial and postdiluvial. The only small craters are those of the later series, as the older have been filled and buried. Craters of the older series have lost in accentuation not only through the paring of their rims, but also through the partial filling of their valleys, and their rims no longer exhbit the fine details of inner terracing and outer furrowing. Compare in these respects Hipparchus, Albategnius, and Alphonsus of the old regime with Alpetragius, Horrox, Theophilus, and Copernicus of the new.

Adjoining this district on the south and extending thence to the south pole is a broad area, known as the honeycomb district, to which the flood did not extend and with which the characters of the flooded district may be compared. In the honeycomb district distinctions of age may, indeed, be recognized, but there is gradation instead of sharp demarkation between old and new. Those parts of the surface which have been longest exempt from the downfall of large bodies are profusely pitted with minor craters, and it is these which dim the outlines of larger formations of ancient date.

Thus, by the outrush from the Mare Imbrium were introduced the elements necessary to a broad classification of the lunar surface. A part was buried by liquid matter whose congelation produced smooth plains. Another part was overrun by a flood of solid and pasty matter which sculptured and disguised its former details. The remainder was untouched, and probably represents the general condition of the surface previous to the Imbrian event.

Furrows.—In strong contrast with all other features of the moon's surface are a series of gigantic furrows. In general direction they are remarkably straight, but their sides and bottoms, with a single exception, are jagged, abounding in acute salients and re-entrants. If one thinks only of their apparent size instead of their real magnitude as he examines them through the telescope, he is reminded of the rude grooves sometimes seen on glaciated surfaces where the corner of a hard bowlder, dragged forward by the ice, has plowed its way through a brittle rock. Despite the enormous disparity in size—a disparity no less than that of a mountain to a molehill—I believe that this resemblance is more than accidental, and that the lunar furrows were really formed by the forceful movement of a hard body; but the graving tool in this case, instead of being slowly pushed forward by a matrix of ice, moved with high velocity and was controlled only by its own inertia. It was my first idea that the furrows are the tracks left by solid moonlets whose orbits at the instant of collision were nearly tangent to the surface of the moon, and for some of them I have still no better explanation to suggest; but when they came to be platted on a chart of the moon's face it was found that more than half of them accord in direction with the trend lines of the Imbrian outrush, a relation which can be seen in Fig. 14, where they are represented by heavy lines. It thus appears possible, if not probable, that they were produced simultaneously with the Imbrian deluge, and the implication of power is thereby rendered even more impressive. What must have been the violence of a collision whose scattered fragments, after a trajectory of more than a thousand miles, scored valleys comparable in magnitude with the Grand Canyon of the Colorado!

So far as I am aware, but four of these furrows have been previously recorded, and only two are well known, the valley near Rheita and the valley of the Alps, and

* Parallelism has been noted by Beer and Madler in the tract south of M. Serenitatis (Der Mond., p. 250), and by Nelson south of the Carpathians (The Moon, p. 300), but no reference is made to sculpture.

I therefore invite the attention of observers to the localities indicated by the following descriptions. Beer and Madler, who set forth the character of the Rheita valley at length and with great clearness, state that it is 187 miles long and from 10 to 25 miles broad and has a maximum depth of more than 11,000 feet.* Its general course runs from the eastern tangent of the crater Rheita southwestward to the northern margin of the crater Rheita *d*. Not far from its southwestern extremity starts a smaller valley with a somewhat more southerly course. Parallel to this latter valley and somewhat to the southeast are a number of minor grooves which give a striated appearance to an area between Metius and Vlacq. One of these can be traced northeastward to a point just west of the crater Piccolomini. Although unquestionably a unit, it is not continuous, but appears here and there as though the projectile grazed only the higher uplands, and it is locally blotted out by the craters Metius and Fabricius, which are of more recent date. Its total length is 450 miles. Another of the same system appears to the northwest of the crater Furnerius. More conspicuous than these and more westerly in trend is a groove seen first at the southern tangent of Borda and traced for 500 miles west-southwest across the southern part of Snellius and past the southern margins of Haze and Adams. Its width is in general about 10 miles, but width and depth are irregular, and it leaps a number of valleys, including the bed of Snellius. Beer and Madler† record a part of it just west of Snellius, but apparently saw no other part. West of the Mare Nectaris and following the eastern base of the Pyrenees mountains is a trough which should probably be classed with the furrow system, but I have not seen it with the illumination suitable for the determination of its details. In length and width it resembles the Rheita valley and it trends nearly with the meridian. It is crossed obliquely by a narrower groove trending approximately with the Imbrian system and intersecting the crater Capella. This is partly represented on Schmidt's map. My notes indicate also a very old furrow trending southeastward from a point about 175 miles east from Clavius, but its precise position was not determined. The straight valley traversing the lunar Alps, better known than any of the others, is likewise exceptional in character. Its sides are no less irregular than those of the other furrows and are even more precipitous, but its bottom is smooth, so that it constitutes a comparatively narrow, flat-bottomed defile, traversing the plateau from side to side. Neison gives its length as 83 miles and its breadth as ranging from 6 to 3½ miles, but at a point near its southern end it is still narrower. Its maximum depth is more than 10,000 feet. Its trend coincides with that of the Imbrian sculpture in its vicinity, and it thus helps to unite the furrow group of the western district with the great sculpture system. The flatness of its bottom is readily explained as a result of partial flooding, but its constriction is less easily explained.‡

Wargentin.—One of the most striking anomalies of the moon's face is the plateau Wargentin. It is a smooth, circular table 54 miles wide, standing several thousand feet above its base and bearing a low parapet about the greater part of its edge. It is readily recognized as a crater that has been filled by molten rock to the level of the lowest point of its lofty rim, and the determination of its mode of filling is a problem that has occupied the attention of all selenologists. A solution consonant with the moonlet theory is suggested by the Imbrian deluge. As already noted, the crater of Julius Cæsar is filled as high as the breach through its southwestern rim. The filling, however, was not even, as the added material was not sufficiently fluent to acquire a level surface. Five hundred miles away, in a district where the deluge was more liquid, the crater of Posidonius shows a level floor at the height of the lowest point of the rim. It happens that the walls of Posidonius are very uneven, and that their lowest pass is only a little higher than the neighboring Mare Serenitatis. Its floor, therefore, does not attract attention as an elevated plateau, but the relation of floor to rim is essentially the same as in Wargentin, and community of origin is a natural inference. Further study will be required to determine the source of the Wargentin accession, but clews are not wanting, for the neighborhood abounds in evidence of flooding. Close to Wargentin's western base lie three craters, of which the nearest, Phocylides *b*, is partly filled and Phocylides *c* is almost completely filled, though the largest, Phocylides, is empty. To the northwest of these and to the south of Mare Humorum is a broad tract characterized by much filling of craters and by the obliteration of minute craters. It has the general aspect of the Imbrian region, but I have not ventured to include it in the Imbrian chart, as it is separated by nearly 200 miles of the Nubian plain from the nearest district distinctly sculptured. If it did derive its overwash from the Mare Imbrium, then that flood extended in this direction more than 1,500 miles and must have swept over the entire Oceanus Procellarum. Be this as it may, Wargentin and the neighboring lowland probably have a common flood history.

Rills and Rill Pits.—Among the most difficult of the moon's enigmas is the problem of the "rills." Narrow defiles, often tapering at either end, they suggest fissures; but fissures taper downward also, and many of the rills have flat bottoms. Deep canyons, with parallel steep walls, they suggest stream beds; but stream beds have continuous descent in one direction, and the rills run up hill as well as down.

Here again the Imbrian deluge affords a clew. Close by Julius Cæsar, and in the same district of pasty—or, at least, non-liquid—overwash, lie the great rills of Ariadæus and Hyginus. The rounding of their edges marks them as antediluvial features; what was their condition before the flood? Certainly not the same as now, or they would have been filled and obliterated. I imagine them as yawning chasms three-fourths of a mile wide at top and several miles in depth. As the swift tide rushed over them a small portion may have been arrested and engulfed, but the chasms were not filled until the torrent stopped. Then that which spanned them sank down, coming to rest a short distance below the edges, and so forming the visible floors. The pits that interrupt these floors are definitely related to the rills and cannot be classed as impact craters. Possibly here and there an arch of debris that had clogged the crevice gave way, letting what lay above it pour into the abyss below. Possibly there was moisture in the crevice, and the inrush brought heat enough to cause explosions of steam. If the floor fell in, the pits should be rimless; if it was blown out, they should be rimmed. I was not able to satisfy myself as to their actual character, and recorded observations are discrepant, but the features are not too minute for accurate determination.

In a part of the rill of Hyginus the pits are set so close that their edges adjoin; other rills are composed wholly of pits, and these lead by gradation of characters to rows of separate pits where no rills are visible. Fine illustrations of the last may be seen along the western base of Copernicus, almost half way to Eratosthenes. If my conjecture is correct, these mark the line of a fissure that was filled by a molten flow connected with the formation of Copernicus.

The rills that have no visible bottoms, but are seen only as black lines, are the unfilled fissures necessary to complete this series of features at the opposite end.

White Streaks.—The only remaining great group of features are the white streaks. These are bands of color, sometimes faint, sometimes brilliant, but always indefinitely outlined, like the tail of a comet, and some of them stretch for long distances across the moon's surface. Their courses are independent of the configuration. They pass up and down the slopes of craters without either modifying their forms or being interrupted by them. The more prominent of them, and probably all, occur in systems, and those of each system radiate from some crater. This crater is itself lined with white and is usually more resplendent than the radiating streaks. We need not take time to consider the various conjectures which have been published concerning their origin. It suffices to say that all but the least plausible of these conjectures have been advanced as suggestions merely and have not been fully indorsed by their authors; but there is an unpublished suggestion, made by Mr. William Wurdemann, of Washington, which is at once so apt and so simple that I am comfident it contains the essence of the theory that will finally be adopted. Mr. Wurdemann is one of a number of students who have independently advocated the metoric origin of the lunar craters, but his views have never been published. In a letter on the origin of the lunar topography, addressed by him to Dr. B. A. Gould, occurs the following passage: "The most remarkable appearance on the moon, for which nothing on earth furnishes an example, is presented by those immense radiations from a few of the larger craters—perfectly straight lines as though marked with chalk along a ruler—starting from the center of the crater and extending to great distances over every obstruction. My explanation is that a meteorite, striking the moon with great force, spattered some whitish matter in various directions. Since gravitation is much feebler on the moon than with us and atmospheric obstruction of consequence does not exist, the great distance to which the matter flew is easily accounted for."

This explanation appeals strongly to the eye. The ray systems resemble splashes so closely that it is difficult to understand why the idea that they really are splashes has not sooner found its way into the moon's literature. It accounts for the straightness of the rays, for their vanishing edges and ends, for their independence of topography, for their relation to craters, for the whiteness of the associated craters, and for the nimbus in which the rays sometimes unite close to the crater. It explains the white crests of many gray craters, for peaks would intercept more than their pro rata of the horizontal shower.

It raises also a number of questions, the discussion of which should throw much new light on the moon's history. What is the white substance? Why do its traces become faint in passing from the bright uplands to the dark plains? Why do wavy lines replace straight ones in the radiation from Copernicus? Why do certain great rays of Tycho's system trend toward a point on the rim and not toward the center of the crater? Why are several craters, especially Tycho, surrounded by a relatively dark band inside the bright nimbus?

As no dark rays emanate from the dark craters, it may be inferred that the white substance is peculiar in its tendency to fly about at the instant of collision. It is probably a readily fusible solid. If the ring of moonlets and the earth were once the outer and inner parts of the same whirling mass, the moonlets should consist of substances somewhat abundant in the earth's crust. Inquiry may therefore be addressed to familiar fusible substances of pale color. Fusibility in this case is measured by a factor involving the initial temperature, the melting temperature, the specific heat, and the latent heat of fusion; and this must be compared with the amount of energy expended in collision. In the short table I have constructed, the energy necessary to melt a unit mass of a substance is expressed as a fraction of the energy of motion destroyed by the collision of a unit mass. The ratios were computed on the postulates, first, of an initial temperature of —273° C.; second, of an initial temperature of —100° C. Ratios are added for the rock diabase, as a possible representative of the less fusible moonlets.

Substance.	Relative energy for fusion from —273°.	Relative energy for fusion from —100°.
Tin	0·06	0·05
Phosphorus	0·11	0·05
Sulphur	0·11	0·07
Silver	0·15	0·13
Nickel*	0·30+	0·27+
Ice	0·33	0·19
Calcium sulphate*	0·43+	0·38+
Sodium chloride	0·46	0·40
Diabase	0·69	0·61

Attention is naturally directed to ice by reason of its abundance on the earth and its whiteness. If it exists on the moon as a solid or liquid, it must also exist as a gas, for it would evaporate until the resulting atmosphere had a certain pressure definitely related to the temperature of the ice. The low temperatures ascribed to the moon by Langley would correspond to an atmosphere of aqueous vapor so tenuous as to be very difficult of recognition; so that the prevalent doubt as to the demonstration of a lunar atmosphere need not bar speculation as to lunar ice. The atmospheric pressure which W. C. Pickering estimates as possible* would indicate a maximum ice temperature of about —40° C. The question whether a moonlet could consist partly or wholly of ice is more vital and more difficult.

Tin, silver, phosphorus, and sulphur are more easily fused than ice and their physical properties are perhaps equally adjusted to the requirements of the problem; but tin and silver are rare substances, while phosphorus, which is less rare, does not occur naturally uncombined, and sulphur, though abundant in combination, is rare in the free state. Perhaps the free iron and nickel of aerolites may stand sponsor for free sulphur or phosphorus in moonlets.

The white bands grouped about Copernicus, though unmistakably derived from that center, do not radiate directly from the crater, are not straight, and are not of even width. They appear also to be diverted by the crater Eratosthenes, passing beyond it on both sides, but leaving a free space in its lee. These characters, and the rill pits previously described, lead me to refer the bands to a swift liquid flow over the surface. The flow probably included two substances, the darker of which, occupying interspaces between the pale bands, is not distinguishable in color from the surrounding maria. The straight feathery rays from other craters are referred, in contradistinction, to jets or sprays projected free from the surface.

Retrospect.—In the preparation of this manuscript I have been gradually drawn from the attitude of the judge to the attitude of the advocate. This transformation is but an echo of the history of the investigation, for starting with two working hypotheses, the impact and the volcanic, I soon found that the details of crater forms accorded so perfectly with my theoretic conception of the results of impact and so imperfectly with the results of volcanic action that further consideration of volcanic possibilities was unprofitable. Brief examination of other theories, as they were discovered one by one in the literature of the subject, satisfied me that they could not compete with the impact theory as interpreters of crater form, and thus I was led to devote myself to the development of the impact theory.

As one after another the obstacles in its path were found to be movable, and as one after another the obscure phenomena of the moon were found to be illuminated by its light, it gradually ceased to be viewed as a tentative explanation and was adopted as the real explanation. The tendency toward advocacy thus sprang from conviction, but it has been further promoted by the consciousness that there are many in my audience who do not share with the student of geophysics his conception of the plasticity of rock masses.

Our everyday experience tell us that rock is brittle, and the correlative fact of its viscosity is not practically accepted on the mere dictum of the physicist and the geologist, unless their paths of approach are to some extent retrod. So results of impact which seem to me entirely natural are to some of you extravagant and inconceivable; and if the impact hypothesis is to abide with you, it must ingratiate itself by an attractive array of accomplishments.

The analytic examination of volcanic processes left the possibility that the small craters of the moon are maars, the results of explosion without eruption of lava; the tidal process might perhaps make large craters, but could not make small ones. These are the only suggested reactions originating in the moon itself which appear competent to produce the crater forms actually observed. Taken together, they cover all the craters, but they cannot be applied as a joint theory without arbitrarily dividing a series the gradation of which is complete as to both size and form. The impact theory applies a single process to the entire series (excepting only the rill pits), correlating size variation with form variation in a rational way. Specialized by the assumption of an antecedent ring of moonlets, it accounts also for the great size of many craters. It brings to light the history of a great cataclysm, whose results include the remodeling of vast areas, the flooding of crater cups, the formation of irregular maria, and the conversion of mere cracks to rills with flat bottoms. It explains the straight valleys and the white streaks. In fine, it unites and organizes as a rational and coherent whole the varied strange appearances whose assemblage on our neighbor's face cannot have been fortuitous.

Growth of the Moon.—In an incidental way there has sprung from this investigation of the moon's craters a theory as to the building of the moon itself. An attempt to develop that theory would lead far afield, but it is due to the crater discussion that its implications as to the moon's history be brought together, so that their coherency may be judged.

In the breaking up of the postulated prelunar ring there were at first many centers of aggregation—were the moon the only center, the scars of impact would all be small. So long as the masses were small the process of aggregation developed little heat, for the heat of impact depended almost wholly on velocities created by mutual attractions. That particular moonlet which became the nucleus of the moon may therefore be conceived as cold, or at least as sufficiently cool to be solid. As the moon's mass grew the blows it received were progressively harder, and for a time their frequency also increased.

The rate of heating probably reached and passed its maximum while the mass was materially less than now. During the whole period of growth the surface lost heat by radiation, but the process of growth cannot have been slow enough to permit the concurrent dissipation of all the impact heat. On the one hand there should have been some storage of heat in the interior and, on the other hand, the stored heat can never have sufficed for the liquefaction of the nucleus. Toward the close of the process, when blows were hard but rare, liquefaction was a local and temporary surface phenomenon, but the general temperature of the surface was low.

Impact heat being evolved simultaneously in the sur-

* Der Mond, page 380.

† Der Mond, page 375.

‡ While engaged in telescopic study I did not realize the importance of close attention to the details of this district, and these pages will go to press before I have opportunity for renewed observation.

* Latent heat of fusion not known, and ratio therefore too small.

* Astronomy and Astro-physics, 1892, p. 773.

face and the subsurface, was dissipated more rapidly from the surface, so that there was a subsurface zone of relatively high temperature. The zone thus inferred deductively is also inferred inductively from the disparity of cavities and rims in the case of large craters; but, on the other hand, there is little evidence of the wrinkling which, theoretically, should result from the adjustment of a cold crust to a cooling nucleus. The parallel topography southeast of Mare Serenitatis is due to sculpture, and not to buckling. The Apennine range, sometimes described as a wrinkle, is part of a crater rim. The great cliff called Altai mountains probably marks a fault, but has not the habit of a range lifted by tangential thrust. The only indubitable flexures that may be ascribed to crustal adjustment traverse the maria, whose smooth floors are admirably adapted to their display. They have anticlinal and monoclinal forms, but are so gentle of slope that they are seen only near the terminator, and can represent but a minute amount of arc shortening. It is therefore probable that the final shrinkage of nucleus was small, and the antecedent storage of heat correspondingly small. During the whole period of growth the body of the moon was cold.

This sketch of the life of our nearest neighbor has but little in common with the accounts of other biographers. To her has been ascribed a fiery youth, after the manner of the sun, a middle life of dissipation, like Jupiter and Saturn, a hardening and wrinkling old age, toward which the earth is tending, and, finally, the end of change, death. If the record of her scarred face has now been read aright, all that remains of the old narrative is its denouement: the moon is dead.

Age of the Moon.—Selenographers are not yet satisfied that the condition of the lunar surface is constant, although the history of their search for changes is discouraging. If the moon's face shall prove absolutely incommunicative of modern change, it cannot be expected to reveal the date when its expression last was varied; but, strange as it may seem, the earth can give a partial answer, for the earth was an actor as well as a spectator of the moon's drama, and the record of its participation lies somewhere among the archives of its crust. While the moon was growing the relations of orbits and attractions were such that any moonlet which narrowly escaped collision with the moon was enormously perturbed, acquiring an entirely different orbit about the earth. Many must have been so directed as to collide with the earth, and the traces of their collision, if ever discovered, will tie together at a new point the chronologies of satellite and planet.

The results of collision with the earth may have been very different from the lunar phenomena. The energy of impact determined by the earth's attraction was twenty-two times as great as that determined by the moon's. It would suffice to melt a body of diabase thirty times as large as the moonlet. The shock was somewhat lessened by the atmospheric cushion, but a moonlet of medium size must have developed an immense quantity of heat, and may be imagined to have projected molten rock far and wide, just as the white streaks were projected over the moon.

Does the earth exhibit impact craters? If not, then erosion and sedimentation have destroyed them, and the Cenozoic era did not witness the building of the moon. Is any horizon of stratified rocks generally or widely characterized by molten disjecta? If not, then the moon was already a finished planet in Paleozoic time. Should both questions be answered in the negative, and the lunar event thus relegated to the hazy dawn of the geologic day, is it then possible that the earth, by taking tribute from the moonlet swarm, introduced into its crust an element of heterogeneity, which initiated not only the differentiation of continental and oceanic plateaus, but the series of geographic transformations of which geologic structure is the record?

Acknowledgments.—Before my final bow is made it is due that a moment be given to recognition of the facilities and aid I have received in the conduct of the investigation. Through the courtesy of Captain McNair, superintendent of the Naval Observatory, and with the cordial co-operation of the astronomers of his staff, I have been enabled to study the lineaments of the moon's face through the great Washington equatorial. The kindness of Prof. Rood and Prof. Hallock accorded me ample space and facilities for experimentation in the Physical Laboratory of Columbia College. The courtesy of Prof. Langley, Secretary of the Smithsonian Institution, and the generosity of Prof. Hale, of Chicago, secured for my study fine series of lunar negatives and photographs.

The progress of my work has carried me in many directions beyond my proper field of physiography into the fields of physics and celestial mechanics, and in these unfamiliar ways my hesitating feet have been guarded and guided by certain masters in those fields whom I am no less fortunate than proud to number among my friends. I refer to Prof. Newton, of Yale College, and to our fellow members, Dr. Barus, Prof. Abbe, and Prof. Woodward.

STANHOPEA LOWII.

OUR illustration gives a representation of this beautiful new plant, which first flowered with the importers of the species, Messrs. Hugh Low, of Clapton, in December, 1892. It was shown in flower quite recently at the Royal Horticultural Society's meeting on November 14, 1893, when it received an award of merit. As will be seen in the figure, it differs from the usual forms of Stanhopea as seen in gardens, in being hornless, in that respect somewhat approaching S. ecornuta and S. eburnea, which has inconspicuous horns at the base of the lip, and in being identical in form only with S. amesiana, a species also imported by Messrs. Hugh Low & Co., and which may perhaps be regarded as a white form of the species under notice. The flowers of S. Lowii have sepals and petals of a whitish-buff color; the petals obscurely marked with small, reddish dots. The labellum is of ivory whiteness, with some purple lines or blotches in the interior of the hypochile. Stanhopeas are not in fashion just now, or this would have been an introduction to have caused a great stir among orchid growers. Years ago the fine collections of orchids staged at the famed Chiswick shows of the Royal Horticultural Society did not disdain to include a large specimen of S. tigrina, Devoniensis, or S. oculata, and whenever exhibited, the Stanhopeas came in for a fair share of admiration. Even now, when seen in flower in our orchid houses, a Stanhopea arrests attention more than many costly species which have not so singular a form, consequently they are tolerated in many places, rather than cultivated in the manner which their extraordinary showy and fragrant though rather fugacious flowers would warrant. S. Lowii is a New Granadan species, and, like all the other Stanhopeas, should be grown in a basket, in order that its descending flowers may be protruded without hindrance. It was described by Rolfe in the *Kew Bulletin*, 1893, p. 63, and in the *Orchid Review*, vol. i., p. 177, Fig. 12.—*The Gardeners' Chronicle.*

STANHOPEA LOWII: FLOWERS IVORY WHITE.

THE CHESTNUT OAK.

QUERCUS PRINUS is by no means a new-comer in our midst, but for all that, it is not nearly so often seen as its merits warrant. A specimen sent to us from the Duke of Northumberland's pleasure grounds at Albury, near Guildford, has induced us to have an illustration made. It is a handsome deciduous or nearly evergreen tree of large size. The general form of the leaf is well shown in the cut; in texture it is firm, rather thick, and of a rich green color. The shortly-stalked acorns are rather large and pointed, of a bright shining brown, set in a tubercled downy cup. The species is very variable, hence many names have been given to it, and much difficulty is experienced in sharply defining the varieties. It is sometimes called Q. Mirbeckii, though we do not find that name in any authentic list at our disposal. Perhaps Q. Michauxii may have been intended, a species sometimes considered as a form only of Prinus. Q. Prinus has a wide distribution in the Atlantic States, extending from Massachusetts to Ontario, and south to Alabama, and west to Kentucky and Tennessee. According to Sargent, the bark of this oak is preferred to that of other white oaks for tanning purposes.

Why the name Prinus came to be attached to an American tree is not obvious. The Greek *prinos* is generally considered to have been the evergreen oak, Quercus Ilex.—*The Gardeners' Chronicle.*

QUERCUS PRINUS—THE CHESTNUT OAK: SUB-EVERGREEN.

THE DRIED APPLE INDUSTRY IN FRANCE.

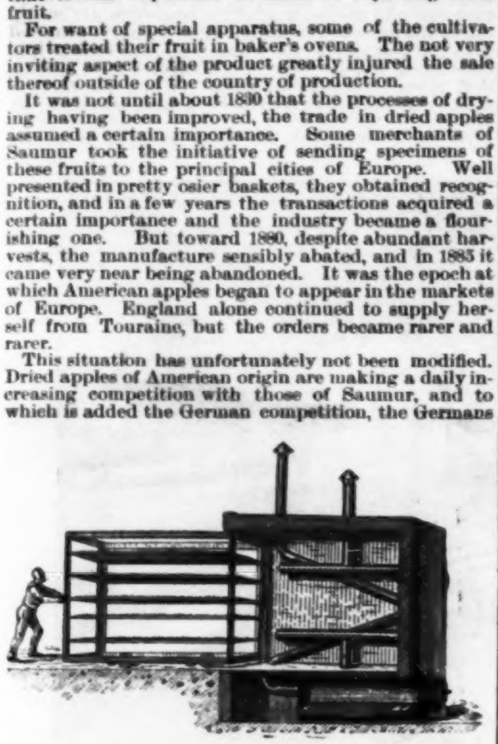
IT is principally in Sarthe, Maine-et-Loire and Indre-et-Loire that the dried apple industry has assumed a relative importance in France. The chief centers of manufacture are Le Mans, La Fleche, Beauge, Saumur, and Chinon. Through the Loire the product reaches Nantes and Saint-Nazaire, whence it is directed toward England. Favored by this exceptional situation, it is now nearly a century since the peasants of this region sought and put into practice a method of preserving

the fruit that they could not sell in years of plenty, while communication with the great centers of consumption was wanting, and navigation was so slow that it was impossible to think of exporting fresh fruit.

For want of special apparatus, some of the cultivators treated their fruit in baker's ovens. The not very inviting aspect of the product greatly injured the sale thereof outside of the country of production.

It was not until about 1830 that the processes of drying having been improved, the trade in dried apples assumed a certain importance. Some merchants of Saumur took the initiative of sending specimens of these fruits to the principal cities of Europe. Well presented in pretty osier baskets, they obtained recognition, and in a few years the transactions acquired a certain importance and the industry became a flourishing one. But toward 1880, despite abundant harvests, the manufacture sensibly abated, and in 1885 it came very near being abandoned. It was the epoch at which American apples began to appear in the markets of Europe. England alone continued to supply herself from Touraine, but the orders became rarer and rarer.

This situation has unfortunately not been modified. Dried apples of American origin are making a daily increasing competition with those of Saumur, and to which is added the German competition, the Germans



RIBES' STOVE FOR DRYING APPLES.

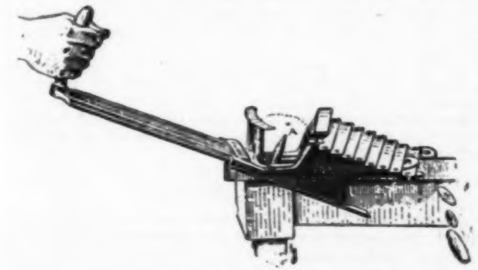
having soon begun to follow the path that the Americans had entered with so much success.

It must be recognized, too, that for forty years, even in the times of the greatest prosperity of their industry, the Saumurians had made no effort to improve their products or to render the preparation of them cheaper. All sorts of fruit were used without selection or discernment—fruit that had fallen prematurely, wormy fruit and fruit gathered too late, and decayed fruit. The peeling and drying were done without much care, and the appearance of the dried fruit left much to be desired.

The Americans, on the contrary, had come to France to make a closer study of the processes of manufacture, and on their return home installed true centers of industry and gave their products an appearance such that those of Saumur could not support a comparison. Then, soon spurning trodden paths and strong in experience, they created entirely new processes of manufacture, and gave especially a new direction to the commercial organization of fruit culture.

In France, for the preparation of dried apples, special fruits are necessary. The two species best adapted to this manufacture are: (1) the golden pippin, often confounded with the Canada pippin, and (2) a local apple proper to Saumur, the farmyard apple. These apples often reach a circumference of 12 inches.

The first, during drying, lose from 75 to 80 per cent. of their weight, and the second less than 80 per cent. All the other species give fruit that is too small or that loses 85 and even 90 per cent. of its weight. This considerably increases the net cost of the dried apples and consequently renders their sale difficult or unprofitable. Such fruit can be utilized only in years of abundance.



For this manufacture, it is customary to gather the apples before complete maturity. In our opinion, this is a bad practice. The picking is done by hand. To this effect ladders are placed against the tree or fruit pickers are employed. The simplest of them is a receptacle composed of small plates in the form of a basket and fixed to the extremity of a pole. The apples are then put into osier baskets and carried to the works, for the industry in improving has been transformed; the desiccation is no longer done on the farm, but by manufacturers, who buy the fresh apples from the peasants. It is necessary that the picking shall have been done with the greatest care, since any blemish will show later on upon the dried fruit. Upon reaching the factory, the apples are peeled with care, the minutest particles of skin being removed with a knife. The bruises produced by birds or the falling of the fruit are also very carefully removed.

Formerly, the core and pips were left in the fruit, but at present it is the general practice to remove them, this rendering the desiccation easier and being easily done with machines.

The apples thus pared are laid side by side upon galvanized iron trays and introduced into a baker's oven heated to 90 or 95 degrees. Therein they are left until, attacked by the heat, the external cells have become hardened and formed a sort of artificial skin. This takes about four hours. The fruit is then taken from the oven and set aside to cool.

Before the cooling is complete, the apples are submitted to a first operation, that of *tapage*. To this effect, they are taken between the thumb and forefinger of each hand, and, on making them revolve, they are slightly compressed with the fingers. Sometimes there is used for this purpose a small tool formed of two boards 4 inches in width and 24 in length, united at one of the ends by a leather hinge.

After undergoing this operation the apples are put back upon the tray, care being taken in depositing them to turn them over, that is to say, to place uppermost the surface that previously touched the tray. The apples are then carried to the oven, which is this time heated to a temperature not exceeding 90 degrees. Herein they remain for five or six hours, and a little longer when the fruit is very large. After being taken from the oven they are pressed a second time, but much more strongly than before, so as to leave in each of them a thickness of but a tenth of an inch at the most. They are afterward put back in the oven for a third time until they are thoroughly dried. Sometimes it is necessary to place them in the oven for a fourth time in order to obtain a complete desiccation.

A few modifications have been recently introduced into the manufacture. There is a tendency to abandon the baker's oven, and many of the manufacturers of Saumur are using stoves or driers. These driers (see figure) resemble the Agen stoves of Marcheron and of Ribes. They have the same system of heating, and we find in them the same shelved car. It is necessary, as in these stoves, to reproduce all the phenomena of oven drying. The trays, placed upon the shelves of the car, are easily introduced into and removed from the drier. The heating is continuous and the fruits remain outside of the drier only for the time necessary to flatten them. The result is a notable saving in time and fuel, but such saving, especially as regards fuel, would be much greater were evaporators employed.

Dried apples fail, in general, with respect to desiccation. The use of the evaporator would permit of obtaining a more perfect and, at the same time, a less expensive desiccation. The drying finished, the fruit is sorted according to size by means of riddles. The large fruit of from 20 to 22 to the pound is put into pretty osier baskets containing from 18 to 35 pounds and shipped to England and Russia.* The medium sized fruit of from 25 to 55 to the pound is shipped in similar baskets to England. This fruit of the second category is delivered to the north of Europe in boxes. The small fruit of from 35 to 40 to the pound is put in baskets or boxes and shipped to Belgium and sold in France.

Dried apples are manufactured with and without cores. The preparation is exactly the same in both cases. The coreless fruit is shipped to every point except England, where the whole apples are preferred, the claim being made that it is the pips that give a perfume to marmalades and preserves. For a short time past there have been manufactured at Saumur sliced apples like those of America. They are dried in the same ovens as the compressed apples. They are sold in cases of 550 pounds. The manufacturers of Saumur claim that apples thus dried in thin slices lose their perfume and taste. We believe that this result is greatly due to the method of drying, for no such complaint can be made of the American apples. And even though the latter had less taste and savor than the compressed apples of Anjou, we could not draw the same conclusions as the Saumurians.

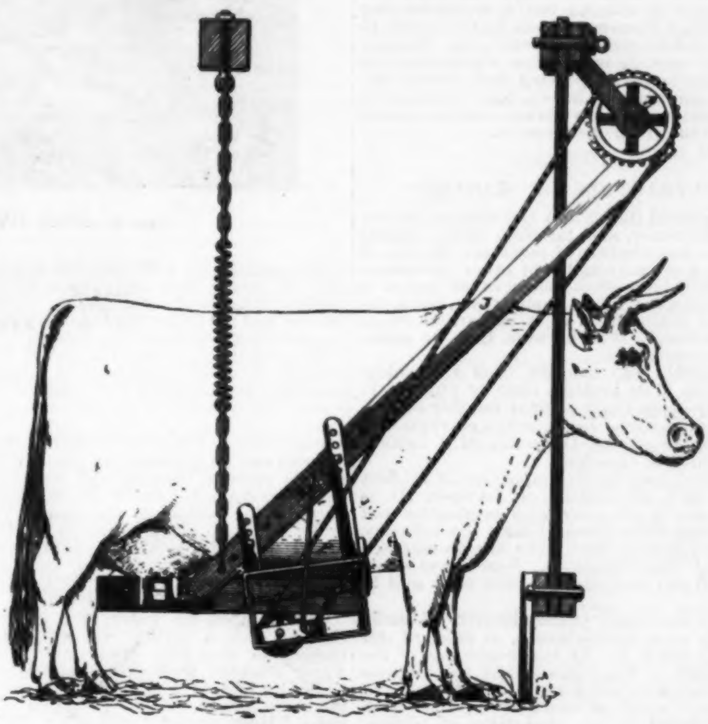
The compressed apples are prepared from selected fruit. The American apples, on the contrary, are prepared from inferior and damaged fruit. This difference of origin would, it seems to us, suffice to explain a difference of quality. In our opinion the compressed apples should be a *produit de luxe*, manufactured with all the special care demanded by a high priced product, while the apples dried in slices or quarters are merely an ordinary product by means of which the producer utilizes fruit that would sell at too low a price in a green state. The compressed apple of Saumur is an industrial product, while the American is an agricultural one.

The waste derived from white fruit amounts to 25 and 30 per cent. The most advantageous manner of utilizing such waste is to convert it into marmalade, pasties and jelly. In order to prepare marmalade, the material is put into a basin with water. As soon as the cooking is finished the contents are passed through a very fine sieve. In order to prepare pasties, less sugar is introduced and the marmalade obtained is spread upon trays and introduced into an evaporator. Finally, to make jelly, the material is cooked in such a way as to obtain a liquid bouillie; which is afterward strained through a piece of linen. —*La Science Moderne.*

A NEW COW MILKER.

VARIOUS mechanical devices have been invented to milk cows. Among them is the rubber glove plan, which fits upon the teats and is connected with an air pump. Fifty or a hundred cows, it is said, may be thus connected with one air pump, operated by a steam engine, and the milk sucked simultaneously from all the udders, and conducted in pipes to a common receptacle. This plan would be good, only it is found not to operate well. The cows' bags are somehow spoiled by the operation, and the milk refuses to flow. Another method is to insert small tubes into teats, to keep them open and allow the milk to outflow by gravity. This also has proved injurious to the animal.

J. Westgarth, of Lily Lake, Ill., is the latest aspirant for milking cows by machinery. His contrivance we here illustrate. The poor cow is confined in a strong frame, and her teats are put between mechanical squeezers. Cams upon a rotary shaft operate the squeezers something after the manner of hand work. Steam, electricity or water power may be used to work the cam shaft. The old cow probably says to herself, "What queer fellows these inventors are!"



PATENT MILKING MACHINE.

THE VILLAGE LEATHER INDUSTRY IN RUSSIA.

THE leather industry is one of the most important in Russia, the production being very large and the trade widely spread among the inhabitants. Statistics show that tanning is carried on as a village industry in 44 governments, occupying about 9,500 households, or about 21,000 men, and that the annual production amounts to 12,000,000 rubles, or about 28 per cent. of that of the factories. The production of wrought leather is spread over forty governments, and occupies 85,000 men, the annual production being about 26,000,000 rubles. The Russian minister of finance has recently issued a report upon Russian industries, in which it is stated that the large manufactories do not compete to any great extent in this branch of trade, consisting principally of boots and shoes, chamois goods, harness and other kinds of wrought leather. A large number of men are also employed in tanning sheepskins used for clothing in the various villages. The value of the annual production of these articles is estimated at 20,000,000 rubles, or about ten times that of the manufactories. It is not known at what precise date the village tanning industry originated; but there is no doubt it existed in this form long before it became a regular manufacturing enterprise. The landowners rendered some assistance toward developing the industry, as it was their custom to apprentice some of their peasants to some form of trade, these young men on their return home practicing their trade on their master's estate. The leather industry is carried on with some difficulty in the various villages, owing to want of capital, insufficient knowledge and difficulties in procuring raw material and in disposing of their goods. The villagers purchase their raw material in the villages and bazars, or from special middlemen. It is also a matter of difficulty for them to acquire the necessary materials for dressing the hides, as they are generally unable to procure bark directly from those who collect it, and are obliged to buy it from the middlemen. The methods practiced by the cottagers are

very simple, even crude and primitive. They have rarely a workshop, but content themselves with the cottage which they occupy with their families. The vat used for steeping and tanning the hides is placed in the street, and the hides are kneaded and greased at home. Their instruments are also very imperfect. The work is generally carried on by the members of the family, and only the more well-to-do peasants hire workmen, and these generally live with the family, receiving wages which vary greatly, according to the locality, from 15 kopecks in the Viatka district to 60 kopecks per day (100 kopecks = 3s. 2d.) in the Vasilsk district of the government of Nijni-Novgorod, their food being provided. In some places, as for instance in the Chernigov district, the peasants club together to buy materials, and work in common. The tanning process lasts but three months in the government of Tver, and from six weeks to two months in the district of Chernigov. The principal consumers are the peasants themselves, who are not very exacting in their choice. The profits accruing from this trade cannot be regarded as very large. In the Viatka district they amount to about 5 or 6 per cent. clear profit of their gross receipts. The highest profits are realized by those who do piece work for the large manufactories, hides and materials all being found. In the government of Moscow a cottager assisted by a family of three persons will dress hides to the value of 1,800 rubles a year, and make a profit of about 13 per cent. Tanning is carried on as a village industry in the governments of Saratov, Perm, Kazan, Penza, Tver, Poltava, Chernigov, Viatka, and in the Terskoi and Kuban districts of the Caucasus. The extent of the trade varies greatly in the above mentioned localities; thus, for instance, in the government of Saratov there are 240 tanners; in the colonies of the Kamyshinsk district there are 165, while in the government of Perm there are 500 village tanners, with a yearly production amounting to 200,000 rubles. In the government of Viatka, although the trade has been of late years developing into a manufacturing industry, the village tanners produce leather goods to the value of 4,000,000 rubles a year. The Russian government and private institutions, recognizing the importance of developing, improving, and strengthening the village industries of Russia, have continually studied this question, and have taken steps to encourage and develop the village handicrafts.

THE EXTRACTION OF KAOLIN.

KAOLIN is a mineral that is now becoming of greater and greater importance, and, far from being limited at present to the manufacture of porcelain, the use of it is extended to a certain number of other industries. Competent authors have often spoken of the use of it in ceramics and of a few other applications, but a description of the exploitation of it as carried on at present is still lacking. It is this want that we desire to supply in these few lines.

Kaolin or porcelain clay consists, from a chemical standpoint, of clay in its greatest state of purity. It is generally white, sometimes colored reddish or yellow by various impurities. Its name is a corruption of the Chinese word *Kauling*—the name of a locality where the substance is exploited.

Kaolin is derived from the decomposition of ancient granitic rocks and principally of feldspar. It is met with especially in company with pegmatites and granites containing white mica. Under the influence of certain neutral agents, these rocks are decomposed at the moment of their formation. Some have given birth to common clay and others to pure clays and to kaolin.

We shall recall the history of the discovery of kaolin in France only as a remembrance, as most of our readers certainly know it. At the beginning of the eighteenth century it was known that the Chinese had for a long time obtained a white and translucent paste for the manufacture of their pottery. In Europe, one was still reduced to the production of faience, when the wife of a pharmacist of Saint-Yrieix discovered by accident a bank of white clay in the environs of that city. Kaolin was found. Since then, the discovery of new deposits in other parts of France has only served to increase the consumption of this valuable product. Thus, at present, kaolin is exploited not only in China and Japan, but also in Saxony, England, Cornwall, Hungary, the Greek Archipelago, and France.

Our country, moreover, is one of the best favored in this respect. We find kaolin of superior quality in Limousin and Dordogne, medium varieties are furnished by Brittany and Allier, and inferior qualities are met with in a large number of localities where the soil is clayey. Fig. 1 represents the great cuttings of the exploitation of Colettes (Allier).

In nature, kaolin is found mixed with the debris of feldspathic rocks, from which it is derived and which are in a more or less advanced state of decomposition.

FIG. 1.—THE COLETTES KAOLIN QUARRY.

It is contaminated with granitic residua, sand, mica, etc. In order to free it from these foreign matters, advantage is taken of the difference of density that they present and of the facility that they possess of holding themselves in suspension in water.

The rock is attacked in the quarry itself by a strong current of water furnished by steam pumps. It is gradually disembedded and becomes mixed with the water, which carries it to the bottom of the quarry. Here it follows an inclined conduit which leads it, after a long journey, to a great decanting basin. The debris of rocks and large stones are removed by laborers during its passage through the conduit. The smaller debris are deposited partly in this same conduit and partly in the bottom of the basin. The supernatant milky liquid no longer contains anything but kaolin mixed with fine sand composed especially of very small grains of quartz, feldspar and mica. The muddy substance goes to a draining well, whence it is lifted by pumps to the surface of the earth.

The pumped up water then enters a circular inclosure with a certain velocity, which diminishes therein so that fine sand only is deposited. The water charged with other materials afterward continues its motion in dividing into several courses 12 meters in length, each terminating in small movable gates. Upon properly regulating the velocity of the liquid by a maneuver of these gates, there are obtained deposits composed of smaller and smaller quantities of sand, always finer, mixed with larger and larger proportions of kaolin, until the water is no longer charged with anything but pure kaolin.

This water is received in vast and quite deep basins called "peats," in which the kaolin deposits and assumes a certain consistency (Fig. 2). The water in excess rises to the surface and is drawn off. This water, however, is not lost, for it is taken up by the pumps and serves anew for attacking the rock. Kaolin is introduced into the peats until the reservoirs are nearly full of the settled substance. Then a plug is removed from the bottom and the whole is allowed to flow into desiccating basins. Here it is subjected to a stirring that gives it homogeneousness. When the paste is sufficiently hard it is shoveled up and taken to the driers.

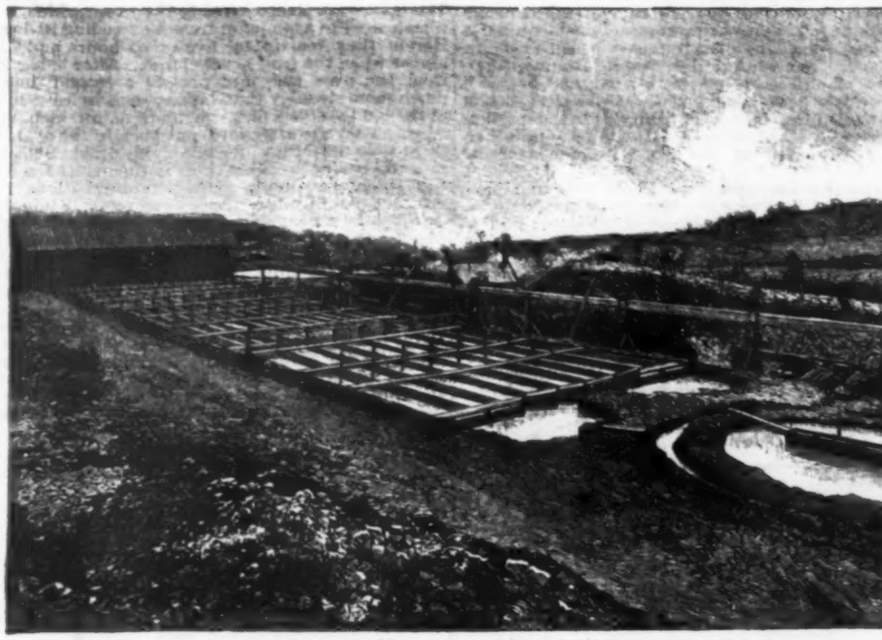


FIG. 2.—DEPOSITING BASINS OF THE COLETTES QUARRY.

We have seen that the water pumped from the quarry abandons in the first place, along with the sand, quite a large proportion of kaolin. In order to extract the latter from these mixtures, each of the 12 meter courses of which we have spoken is put in communication, through the removal of a plug, with a conduit that carries the deposits to an establishment situated at a lower level. The mixtures of sand and kaolin are then sent from time to time, through a discharge of water, into this establishment below, where the operations that we have just described are renewed.

The driers are distinguished as air or fire driers. The object of the latter is to assure the continuity of the production, notably in the inclement season, when the air driers are inadequate. The kaolin after desiccation can be delivered to commerce. One of the greatest drawbacks of the kaolin industry consists in the continual modifications of the canalization of the water designed to attack the rock, and which must, in fact, vary according to the direction, thickness, and extent of the banks of kaolin under exploitation.

As for the deposits of foreign substances that are produced in the different decantations, they serve for various purposes. They are formed of variable proportions of kaolin, quartz, mica and feldspar. They enter into the composition of stone ware and artificial pumice stone, and it is also these elements, that, after baking, furnish materials of great strength and hardness.

Alongside of the exploitation of kaolin we always meet with accessory industries that are no less important. Kaolin, derived from the decomposition of feldspars, generally accompanies banks of common clay, use for which is found in the manufacture of bricks.

As for kaolin properly so called, its friability, its softness, its plasticity, its resistance to chemical agents, and, in a word, the various properties that characterize it, render it suitable for a host of applications that we intend calling attention to in another article.—*La Nature.*

HARDWOOD JOINERY.*

A PAPER on this subject was read recently by Mr. H. W. Barnes, of the firm of Brindley & Farmer, Westminster Bridge Road. It was illustrated by a large number of specimens of varieties of oak, teak, mahogany and walnut, and by examples of old balusters and canopies, by a church screen in Hungarian oak, worked by the lecturer's firm, and by working drawings. Mr. Barnes explained that he intended to restrict himself to modern hardwood joinery, and proceeded: For its production, if the work is to be really good, two things are absolutely essential: good workmen and good, well-seasoned wood, for it is as impossible for a good workman to produce satisfactory work with bad material as it is for an inferior workman to turn out creditable work, however good the material may be.

A short review of some of the hardwoods more generally used may therefore be of interest. Oak naturally takes precedence, and of this there are several varieties—English, Russian, Hungarian and American being the principal. Of these English still stands unrivaled for strength and durability under exposure; but it has been superseded to a very great extent for internal fittings by the others, which are easier to work, and from their milder nature less liable to twist or crack. English oak trees are usually felled early in the year, when the sap has risen, on account of the value of the bark, which is then easily stripped off and used for tanning leather; but oak so felled takes

* Before the Architectural Association, London. From the *Building News.*

about two years longer to season than that felled in the winter. In the latter case, however, the bark cannot be stripped off, and is therefore wasted. English oak trees at times produce planks of great width, one cut down some years ago at the scene of your last summer excursion (Diss) yielding perfect ones 5 ft. wide.

Undoubtedly the finest oak available of late years for interior work has been the variety of Russian, known as Riga wainscot, the grain being very fine, close and regular, the wood a good color and easy to work; but the logs, never very large, are now smaller than ever—in fact, it is very difficult to get them at all, the supply being nearly exhausted. Several other kinds are also shipped from Russian ports; these are principally cut from small trees; the grain is coarse, and, as a rule, they are unsuitable for good work. Hungary produces a very fine variety of oak. The logs are much larger than any formerly shipped from Riga, and at the present time this is certainly the best oak available in any quantity, its great width making it specially valuable for panels. This is shipped at Fiume, in the Adriatic. Hungary, as well as Russia, also produces, however, some very inferior sorts. America sends large quantities of oak to this country; but it is not equal either to Riga or the best Hungarian. The grain is very open, the color poor, usually with a pink tint, and, generally speaking, is unsatisfactory for high-class work. The silver grain is a distinguishing feature of oak and produces the figure. These lines are absent in chestnut, and in many cases form, probably, the only way of distinguishing the two woods. One other point respecting oak is worth referring to—the term "wainscot." This does not distinguish any particular variety or locality, but is applied indiscriminately to all logs cut on the quarter.

Mahogany next claims attention, the different kinds varying considerably, that known as Spanish, coming from San Domingo, being the most valued. In the past this has been extensively used, but is now very scarce, its place being taken by another Spanish variety found at Cuba, which is very close-grained, hard and of good color; but the kinds more generally used at the present time are obtained from Tabasco and British Honduras; Panama and Africa also send mahogany to this country, but the quality of both is very poor.

Of walnut, five descriptions deserve notice, Italian coming first, both for closeness of grain and beauty of markings. This is difficult to obtain at the present time, but a variety much resembling it is now imported from Circassia. English is lighter in color and not so richly marked. A totally different kind, known as black walnut, is shipped at Quebec: it is much softer than the others and almost devoid of markings, but can be obtained in large sizes, and is not likely to crack. A lighter shade of the same wood is shipped at New York and other United States ports. Teak is imported from Burmah, and is especially valuable for work exposed to sea air and salt water; it is also coming into very general use for hospital floors; a variety is found at Bangkok, but the color is not so good. Many devices have been tried for artificially drying hard woods in a short time; but all seem open to objection of some kind or other, and allowing the wood to season by the natural action of the air on the boards and planks is, after all, the most satisfactory, although it is a long process. But it is time to pass from the material to the various methods of working it. Starting at the beginning, the selection of the wood before it is cut to size is more important than appears at first sight, for on this much of the final appearance will depend, and too much care cannot be exercised at this stage, for carelessness in matching will prevent the work ever looking really well, and most likely result in considerable waste. Cutting to length and width is now done entirely by steam saws; afterward the wood is passed through a trying-up machine, which planes it to thickness and width, leaving it quite true and ready for moulding; mortising and tenoning are also done by machinery and absolute truth secured.

So far, machinery is of advantage in every way, and it also relieves the joiner of the very hard labor necessary before its introduction, leaving him free to devote all his energies to the remaining parts of the work, in which a good workman will find plenty of opportunity to display his skill. Up to this point the preparation of all hardwood joinery is practically the same (nor does it differ materially from soft woodwork); but as in its further stages the methods diverge considerably, it will be well to consider these under two broad heads: First, the simpler forms, in which machinery continues to play an important part, and afterward the more elaborate work, which has frequently to be done almost entirely by hand. Formerly mouldings were worked either by planes of various shapes or by routers. The latter were of steel, much the same as modern machine irons, but let into a piece of wood and worked backward and forward by hand—a long and tedious process. The introduction of machinery has, however, done away with both these methods, so far as the ordinary mouldings used for domestic fittings are concerned. In such work the mouldings can and should be turned out in such a manner as not to need touching by hand, and when cost is of great importance, care should be taken that the sections are such as can be worked by passing once only through the machine. Before further considering the question of sections and the important bearing they have, both on the appearance and cost of work, it may be of advantage to call attention to the practice followed of cutting boards and planks to the nominal thicknesses of 1 in., 1¼ in., 1½ in. and so on; but as the saw-cut and planing have to be taken out of this, they never hold the full thickness when worked up, 1 in. finishing ⅞ in., 1¼ in. 1⅛ in., 1½ in. 1⅜ in. Therefore (paradoxical though it may seem), it costs more to produce work 1¼ in. thick than 1⅜ in., for 1½ in. boards must be used in each case, but there will be increased labor in reducing them to 1¼ in. Planks also finish about ¼ in. less, and wide English oak ones sometimes even ½ in. less, as, on account of the greater strength of their grain, the latter are more liable to twist in drying. By keeping this in mind unnecessary waste may frequently be avoided.

Cornices, cappings and similar mouldings will stand infinitely better if built up, and be far less likely either to twist or crack than if made solid, the result being better work at less cost. Care must, however, be taken that each part is properly tongued or cross-tongued. Construction deserves more than a passing notice, for on it very much depends, and every detail should be carefully thought out. It is difficult to lay down any hard-and-fast rule on the subject, as each work should be considered on its merits; but mortises and tenons are always safe and reliable. In the case of very thick doors, however, it is sometimes desirable to put these double rather than single, to avoid any possible warping of the stiles. Where, however, mortises and tenons cannot be employed, handrail screws may frequently be used with advantage. Dovetails are also very good, but apply more especially to sashes and cabinet making. Wall panelings, dados and skirtings should always be tongued together at the angles and into the floor, otherwise dust will find its way between and underneath them, possibly forming a harbor for the germs of infectious disease. Flooring should be laid in narrow widths and tongued at the joints; this gives every opportunity for good secret nailing. Large columns will never stand if made solid, but will crack and twist out of all shape. If, however, they are made in sections, the difficulty is entirely avoided, the result being very much better work at no increase of cost, but rather the reverse. When great strength is required, such as in an open-timber roof, solid wood must, of course, be used.

The various systems of mitering next claim attention. In cheap joinery the work is framed up square and the mouldings mitered in afterward on the top of the panels; but this method is open to serious objection, the stability of the mouldings depending entirely on nails driven in at an awkward angle, and if these chance to go through the panels instead of into the stiles and rails, and the panels shrink, the result will be an unsightly crack. Except in the case of bolection mouldings, which can be rabbeted onto the stiles, etc., and properly fastened, this treatment should never be adopted for good work. An infinitely better system, and the one usually employed in high class joinery, is to work the mouldings on the solid of the stiles, rails, etc., cutting out the stiles to receive the rails, and so forming a miter. A third method is applied more especially to ecclesiastical joinery. When the work is ready for framing up, it is most desirable to put it together and let it stand as long as possible before actually gluing and wedging, as, no matter how dry the wood may be, it is sure to shrink when first worked; in fact, there are well-authenticated instances of this occurring when reworking old beams which have been in position for 200 or 300 years. Framing up and cleaning off afterward are two very important matters. Shoulders, which in soft woods need hardly be touched after leaving the machine, must, in hard woods, be gone over carefully by hand; otherwise good results cannot be obtained. Miters, too, demand very special attention. For all such work the tools differ very materially from those used for soft woods, the most effective having either metal faces or being entirely of metal. In finishing off, these tools are also of the greatest assistance, as glasspaper should on no account be used. But it is when the more elaborate and intricate forms of ecclesiastical joinery are entered upon that the greatest demands are made on the skill of the workman.

Ancient work was, of course, all done by hand, and still fills us with admiration for its beauty, variety and general excellence. Evidently in those days time was only a secondary consideration, and nothing was spared to make the work worthy of the high purpose for which it was intended. Unfortunately, at the present day, time is of so much importance that it is very difficult to devote the same amount of it to any particular work as the old men did; but there is ample proof, even now, that when cost is not the first consideration, work of high quality can still be produced. Vaulted canopies require much care. These, if of any size, should be built up; if worked in the solid they will crack and twist, utterly spoiling the effect, and will, in addition, be much more expensive; but if the ribs are worked singly, to the required sweep and section, rabbeted for the spandrels, then mitered together, the spandrels filled in afterward and the whole covered at the back with strong canvas well glued, they will stand. Very small and specially elaborate canopies must, of course, be cut out of the solid to a great extent. The third system of mitering, already referred to (known as masons' miters), now claims attention. It consists in working the returns of the mouldings in the solid of the stiles, to stop those on the rails, and on the rails and sills to stop the mullions. The actual working of these returns is done after the work is glued up. It is of necessity a more costly method than the others, but there can be no doubt that in certain work it is the only proper way and far stronger than any other. Much old paneling was filled with linen fold panels, which always look well. These, however, seem to have fallen into disuse, which is to be regretted, more especially as they are really inexpensive, considering the good effect produced, the play of light and shade being very pleasing.

In tracery great opportunities occur, but it is only when cut by hand that all its beauty is brought out and endless variety can then be obtained. When, however, cost is of supreme importance, the aid of machinery can be called in, and by its use the mouldings worked, leaving only the angles and pockets to be done by hand, and if the cusp points are simply turned out, the cost will be still further reduced; in sunk tracery the various sinkings can also be done by machinery; the least expensive section consists of a hollow, a second member, more especially if it is a bead, considerably increasing the labor. How to treat the face of hardwood joinery frequently requires much consideration. In the case of oak, the action of the atmosphere would tone it down admirably; but this takes time, and the first appearance of newness is often removed by the fumes of ammonia, which can be regulated to produce any desired shade, and the treatment is a good one when the work is not subject to much handling; where it is, however, beeswax and turpentine are generally applied afterward, as otherwise the damp heat of the hands will leave dark marks; care must, however, be taken that as much of the wax is rubbed off as possible, or the work will very probably turn yellow in time.

After this application the oak will cease to darken, as the wax fills up the pores and prevents any further action of the air. Beeswax and turpentine alone also produce good results on most hardwoods when well rubbed in, and a very pleasant surface is the result, much the same as the slight polish seen on an eggshell. This treatment is also particularly useful for floors; these, however, require periodical attention. Simple oiling is never satisfactory. French polishing is a very general treatment, but is too well known to need any description. It is of vital consequence to remember that damp plays havoc with seasoned woodwork, causing it to swell and warp; it is therefore fatal to put it against damp walls; when it is impossible for these to have time to dry, the wood should be well coated at the back with a damp-resisting preparation, and not be fixed close against the wall. Hardwood joinery is a dry subject—in fact, so essentially a dry one, and affording so little opportunity for making a paper on it attractive, that it is much to be feared the present one has caught the infection and become in its turn thoroughly dry; still hardwood joinery is a matter which deserves some attention, and possibly the facts placed before you may induce a further study of the methods of working, which will certainly prove useful. The introduction of machinery, although materially reducing the cost of production, has not by any means done away with the necessity for skilled workmen; skill, however, can only come by practice following long and careful training, and in some respects the two essentials requisite for thorough work—good workmen and good materials—bear a strong analogy in the careful preparation both require; the forest may contain the finest trees, but unless these are properly converted and allowed to season, much of their value is lost, and a youth may have all the natural qualifications necessary to make a good workman, but without proper training is never likely to reach a high standard of excellence; both the seasoning of the wood and the training of the youth require time.

It must be a matter of regret to all who have the true interest of the British workingman at heart that the system of apprenticeship has almost died out. No doubt it entailed much drudgery, but it gave a man a better insight into his trade and a more thorough mastery of all its details than can possibly be obtained by any other means. Really good men are as much in demand as ever they were, and the more care and attention a man bestows on his work and the greater the skill he brings to bear upon it, the more likely will he be to insure what every good workman desires—constant employment; and beyond this he will have the satisfaction of knowing that he is doing good work—a satisfaction dear to every earnest and honest worker, be he artist or artisan.

THE COLUMBIAN EXPOSITION.

IV. LIBERAL ARTS—ENGLAND.

By L. P. GRATACAP.

AMONG the ceramics of England considerable attention has been drawn to the Elton ware, a rather bizarre group of forms in dark and mingled colors, imitating in design the Inca work of Peru. Lord Elton is favorably situated for carrying on his original experiments, as his domains inclose a valuable clay bed, and their distinguished owner has been led by this accident and natural taste combined to establish the potteries from which these novelties emanated. They have proved very popular and their sales surprised the agent who accompanied them to the Exhibition. They suggest the American Rookwood in a way, but are less delicate and dainty, and are semi-barbaric in form and accessories. Still they possess intrinsic interest and much of their coloring is rich and artistic. The exhibit of Staffordshire ware by the Moore Brothers was one of much beauty. The white ware with garlands of flowers and raised ornamentation, the orchid designs also, were very beautiful and natural, and much of it original. Amori were, perhaps, for a chaste taste, somewhat too abundantly used. A. B. Daniell & Sons, of Wigmore Street, London, exhibited the superb *pate sur pate* vases of Mr. Solon.

Here was the famous Jubilee vase prepared for the semi-centennial of the Queen's reign over England, a *tour de force* of the most splendid and supreme vigor. Here is shown the happy and captivating design of the Cupids liberating the enchanted nymphs, whom the severe Minerva had confined. The execution and drawing are very expressive and pleasing, the detail painstaking and the whole from every point of view a miracle of technical power and skill. On the other hand all of the work of this firm is not confirmatory of the highest praise. Perhaps it is pedantic and unreasonable to encourage too persistently a demand for constant freshness, and yet only by such means are new efforts made to realize new ideas, and the panorama of the arts more effectively unfolded and extended. In much of the Daniell ware there was a conventional splendor of color and ornamentation which did not seem distinctively artistic.

The Ault faïence of Swadlincote was a rather commonplace and coarse pottery in yellow, blue, green, red, and darker tones. Much of it was in the design of flower pots. The Swadlincote potteries were established in the beginning of the century by Mr. Thomas Sharpe, and are still carried on, we believe, by the Sharpe Brothers. Here were made the "Derbyshire ironstone" ware, embracing "plain and pressed jugs and mugs; bowls of various kinds, ewers and basins, teapots, cups, and jars of various kinds; beef, bread, jelly, stew, and other pans, and every description of household vessels." The "Toby Fill-pot" jugs were made here, and a general assortment of rustic and half humorous articles, while sanitary pottery has occupied the attention of these potters for years and has been extensively used.

Doulton ware, which made such an impression at the Centennial Fair in Philadelphia, was no less conspicuous nor less admired in Chicago. It perhaps became the center of the ceramic exhibit in the English section. Here were glorious examples of ware both in the natural and academic styles, with strength in each. The wonderful Lambeth vases, the plaques, the orchid decoration, the *motifs* from classic fable and the profusion of forms and types made this exhibit a difficult study. Yet amid the variety the eye turned with extreme satisfaction to the blue and brown tankards with romantic decoration. They seem more characteristic

and more interesting. Jewett's remarks (Ceramic Art in Great Britain) are appropriate; he says: "Many of the productions in this stoneware are of extremely artistic character, and evince a purity of taste which is highly meritorious. Some of the jugs and tankards, from antique examples, and which are produced both in brown, blue, claret, and fine white stoneware, are remarkably chaste and elegant, and remind one of the best periods of German and Flemish art. The forms are admirable, and the decorations, whether foliage or animal, incised or in relief, are always thoroughly well considered, and especially adapted to the material, the mode of production, and the use of the object. 'There are no affected imitations of antique types. The spirit of true design is caught with admirable perception and insight, and when color is introduced, it is done sparingly, and with a view to enhance the form of the object and the natural beauty of the material, rather than to conceal either the one or the other.'"

The Coalport china which attracted so much attention was exquisite. It marked the refinement of appreciative decoration, though not very strong or distinguished in design. The Royal Worcester ware was sumptuous. The profuse use of gold in its decoration somewhat vulgarized it. Among the pieces the banquet set, in coral, gold and ivory, with satyr *motif*, was the most striking. The foreign exhibits in the Liberal Arts building were of great importance. Their effect upon all classes of visitors was marked. Great in all respects as the Columbian Exposition has been, perhaps the more marvelous effect of its educational power, in the improvement of the great masses who were introduced by it to a world of beauty and achievement undreamed of by them, will prove to be the greatest.

PORTABLE OIL ENGINE.

At the ninety-sixth annual show of the Smithfield Club, recently opened in London, Messrs. Weyman & Hitchcock exhibited their Trusty oil engines of new form with a single cylinder. The engine now exhibited and illustrated below is of 3¼ brake horse power, runs at 240 revolutions per minute, and has a fly-wheel of 4 ft. in diameter. It is arranged on a bed plate and frame, with water tank beneath and oil tank between the frames. As will be seen from the engraving, it makes an exceedingly handy little portable engine, and makes a very useful addition to the various forms of the Trusty engine made and originated by this firm. —*The Engineer.*

BURNED CLAY BALLAST.

By S. E. Coombs, Assistant Engineer Hannibal and St. Joseph Railroad.

In localities where gravel beds cannot be found, and broken stone is considered too expensive or is of too poor a quality, the so-called burned clay ballast has come into extensive use, and some of the large railway systems in the Missouri Valley are using it in preference to any other ballast. In locating a pit or kiln, a good clay is sought, and almost any clay can be used if free enough from sand. A light clay is preferred on account of ease of handling. The so-called gumbo is used throughout the West and in Texas it is proposed to turn "black wax" to some account by making ballast of it. As the available clay is always on bottom lands, it is often difficult to obtain good drainage, but the importance of this must not be underrated, as on this very factor will often depend the economical working of the kiln. Consideration must also be taken of the prevailing winds, so that they will help both to dry out the clay and fan the fires. The kiln and tracks are arranged, as shown in Fig. 1, varying with the ground.

The working track is simply laid on the surface, so that it can readily be thrown. No very heavy work comes on it till ballast is loaded out. The kiln is started on a triangular core of old ties and kindlings (Fig. 2) piled about 3 ft. high, and the entire length of the kiln, which varies from 2,000 to 4,000 ft. The kiln is often started for a short length, say 2,400 ft., and lengthened as economical working permits. This core is filled with coal and covered about a foot deep with clay, and the fires are lighted. After this has burned down somewhat, the work is begun on the side toward the working track. The laborers simply cover the side of the kiln with the layer of coal and this coal with a layer of clay 6 in. to 9 in. deep. The work is carried on by hand until a sufficient height is reached to use the machines. When the clay is, in the opinion of the operator, sufficiently burned, the kiln is drawn; that is to say, part of the unburned clay is drawn off the fire and a layer of coal scattered over the surface sufficient for burning the next layer of clay, which is from 6 in. to 9 in. thick. This is shown by Fig. 3.

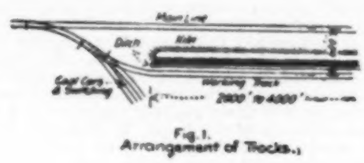


Fig. 1.
Arrangement of Tracks.

Fig 2
Section of Kiln at Starting
Main Line on Left.

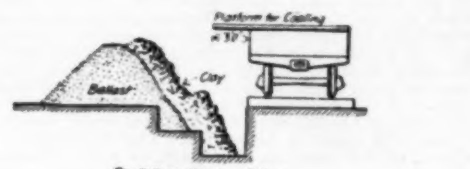


Fig. 3. Cross Section of Kiln at Beginning of Machine Work

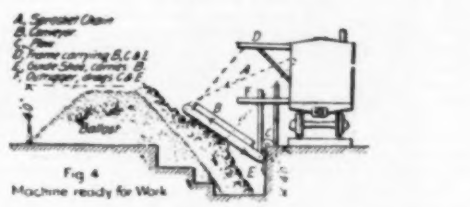


Fig. 4
Machine ready for Work

The spreading of coal is done entirely by hand from a platform about 10×3 ft., rigged over the side of the gondola car which carries the coal, and which can be transferred to each car. Scoop shovels are used, and with very little skill the operators can distribute the coal thoroughly over the surface of the kiln. Coal is also distributed over the surface of the ground, before plowing, so that it gets mixed in the clay and helps to start the new fires after drawing. The plowing, both from the sides and the bottom of the ditch, is done by the machine.

The plant is simple, consisting of two double engines, one set of 10 H. P. and one of 5 H. P., mounted on a flat car. The 10 H. P. engine is geared to trucks for locomotion and also does the plowing; the other runs the conveyor, which distributes the clay over the kiln, both operated by one man. Alongside the car on the rigid frame (but itself movable) is the plow. The conveyor is independent of this, and has one end just below it, so as to catch the dirt which is plowed from the sides of the pit. These conveyors are rubber belts, four feet wide, and are run by sprocket wheels or by friction, and are adjustable. The cost of one machine complete is about $3,500.

The method of operating machines is as follows, and is easily understood by reference to Fig. 4. Clay plowed from the bottom of the ditch is piled up by hand to a height of about four feet to make a sort of shoulder. The plant is then put in motion at a speed of about 200 ft. per minute, plowing from the side and distributing at the same time. When the height of the kiln gets beyond reach of this machine another is put into service with it, having a longer conveyor to reach the top of the kiln. The operation is kept up, requiring no skilled labor except in the superintendence and running of the machines. The principal object is to keep the fires always well covered with clay and burning. The fuel used is ordinary slack coal, and almost any variety of soft coal will do the work. About 560 lb. of coal will burn about a cubic yard of ballast.

Along the Missouri and Mississippi valleys the best season for burning is from just after the so-called June rise to the spring rains. The work is usually done by contract, the railway company furnishing the land, tracks and coal. This method gives the best satisfaction, as the contractor does not feel bound to save coal, which would result in underburned ballast. Partial estimates are given on kiln measurements and the final estimate is made from car measurements when loaded out, so that worthless material is not paid for.

About 1,000 cubic yards per day can be burned in a kiln 4,000 ft. long, and about fifty men are required to operate such a kiln. The cost of ballast thus made is about $1.05 per cubic yard, distributed as follows:

	Cents.
Contract price for burning	*38
Average cost of coal per yard	21
Loading on cars	8
Distributing	9
Putting under track	22
Interest and depreciation on track	4
Land	1
Miscellaneous expense	2
	$1.05

The ballast makes very handsome and easy riding track and has been found satisfactory on most roads where rock is too expensive as compared with it. It is very light, weighing only 40 to 50 lb. per cubic ft., and is thus liable to wash away. Its lightness, however, enables it to be handled cheaply. The principal objection to it is its low crushing strength, making it liable to powder up under the ties and compelling shovel tamping, which is of itself often considered a great objection. It requires renewal in from six to eight years; is quite free from weeds, which are readily cut out; and is said by one superintendent to be easier on rolling stock than any other ballast on account of its elasticity. Figures for this are, however, practically unobtainable.

Track keeps in surface about one-half as well as with broken stone and about the same as with gravel. The same cross section is used as with stone. It cannot be used sparingly, as less than twelve inches under the ties will not give good results. Whether its use is economical is a question of management and locality. Side by side with good stone, however, the latter has the advantage in its superior permanency and stability. The process and machines are patented to some extent and the work is generally done by the patentees.

The cost given above, from five pits, is an actual average, and is high rather than low, as a contract for 50,000 cu. yds. was let this year for burning at 25 cents per cu. yd., an extremely low price. The Wabash Railroad is paying 38 cents, I believe, near St. Louis. I have watched its behavior in the track very closely, and do not think it compares favorably with stone, especially in cost, though of course this is somewhat a matter of opinion. Section men like it because it is so easy to work. The general manager and the general superintendent of the Hannibal & St. Joseph Railroad and allied roads, the general superintendent of the Burlington & Missouri River Railroad, and the division superintendent of the Wabash Railroad are very much in its favor. The chief engineer and two roadmasters of the Hannibal & St. Joseph and Michigan lines and the resident engineer of the St. Louis extension are opposed to it. It may be in the future that the process will be improved so as to make a really first class ballast. The "black wax" experiment is very recent, but bids fair to be successful. The patentees are the Stubbs Ballast Co., Weston, Mo.; the Western Burnt Clay Ballast Co., Cameron, Mo.; and the Davy Clay Ballast Co., address unknown. All three have furnished ballast to the Hannibal & St. Joseph Railroad. —*Engineering News.*

THE "TRUSTY" PORTABLE OIL ENGINE, 3¼ BRAKE HORSE POWER.

THE ANTOFAGASTA AND BOLIVIA RAILROAD.

It is a singular fact that, while the attention of the world has been drawn to the efforts at building the Trans-Andine Railroad between Argentine and Chile, which still remains unfinished, and the Central (Oroya) Railroad in Peru, which was only opened to Trans-Andine traffic within the current year, the Antofagasta and Bolivia Railroad was quietly pushed across the Andes and has for several years been serving an extensive commerce between the lofty Bolivian plateau and the Pacific Ocean. Its present length of line is 574 miles, terminating at the Bolivian city of Oruro, which point was reached by the extension from Uyuni less than a year ago. A location has been made for a continuation of the line to La Paz, the capital of the republic, a distance of 139 miles, and surveys are in progress for a branch from Uyuni to Potosi, about 60 miles in length.

This road was built chiefly to serve the needs of

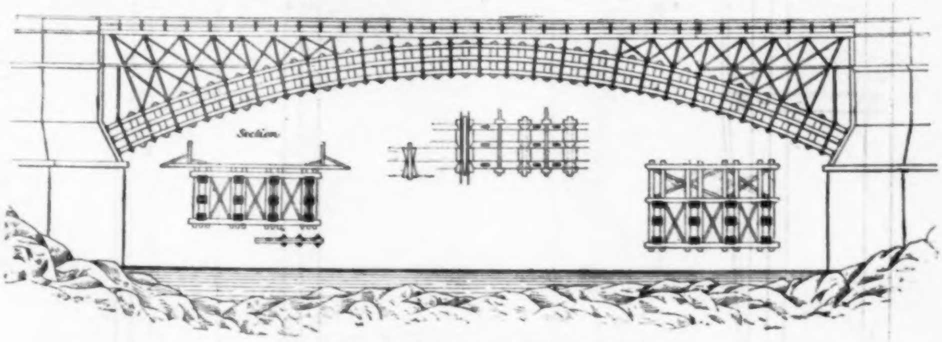
* Variable; this was the price in 1892.

mining interests along the route, those of the Huanchaca of Bolivia silver mining and reduction company being the most extensive. The works of this company are, in fact, the largest of the kind in the world owned and operated by a single corporation, and the capital for building the Antofagasta and Bolivia Railroad was derived almost entirely from the Huanchaca of Bolivia company.

Although not the first railroad in South America to cross the Andes, being preceded by the Southern Railroad of Peru, it is at present altogether the most important of the three existing trans-Andine roads, and would seem destined soon to constitute a link in a trans-continental connection through Argentine upon the building of the proposed extension of the National Central Northern Railroad northward from Jujuy. It is cheaply constructed, as befits a pioneer enterprise in a country where railroad building is difficult and expensive, and in this respect should stand as a model of wise practice for the promoters of other pioneer lines in the Andean regions of South America; except in the matter of gauge, which is 30 in. The track is laid with 36 lb. steel rails, and the traffic carried on this line in 1892 amounted to 416,166 tons of freight and 21,741 passengers. Its gross income for the year was $1,235,316, or $2,152 per mile. The operating expenses amounted to $804,847, thus leaving a net income of $430,469. Of the operating expenses, $33,590 went for costs of administration, $210,724 for movement of locomotives, and $222,832 for maintenance of way and structures, the remainder being distributed among repairs to rolling stock, telegraph, employes on trains and at stations, and police. The above figures are only approximate, being reduced from pesos at 30 cents. The locomotives in actual service number 46, which ran a total of 1,543,570 miles in 1892, being an average of 3,360 miles each.—*Railroad Gazette.*

THE PERADENIA BRIDGE, CEYLON.

ONE of the noticeable things to be seen on the line of the Ceylon Railway between Colombo and Kandy is the "satinwood" bridge located about four miles from Kandy, the ancient capital of Ceylon, on the high road to Colombo, crossing the Mahavilla Ganga. A good view of the structure can be obtained from the railroad. The original intention was to construct the bridge of satinwood, but the plan was not wholly carried out, as the supply could not keep pace with the demand, and millewood was used to some extent. The general appearance of the bridge is shown in the accompanying engraving, reproduced from *Indian Engineering*. The span of the arch is 205 ft. and consists of four sets of treble ribs, connected by dovetailed keys. The dimensions of these ribs or arches are 18×24 in., 16×24 in. and 16×24 in., respectively, formed of beams 12 in. thick, and 18 in., 16 and 14 in. deep, secured to each other by large dovetailed keys fitted into mortises cut transversely through the beams. The arches or treble ribs were tenoned into wooden sleepers placed against the abutments. The

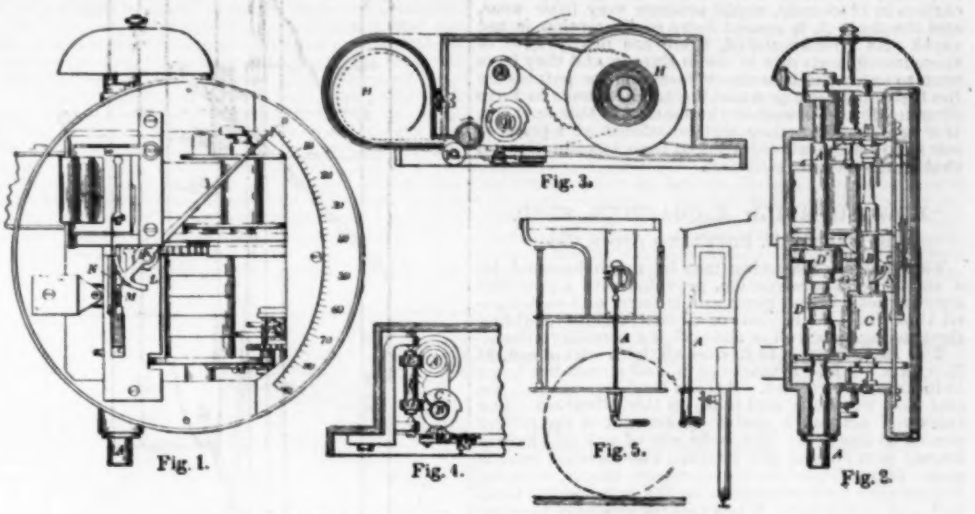


THE PERADENIA BRIDGE, CEYLON.

bridge as thus constructed was completed and thrown open for traffic in 1833. From causes, however, to be expected in the climate of Ceylon and in work of this kind, the entire arch had to be renewed with teak timber in 1855, and that was very ingeniously done without any cessation of traffic. Viewed in any way, the bridge cannot fail to be regarded as a most interesting object; for not only is it a most pleasing picture, but a remarkably novel structure.—*The Railway Review.*

THE HAUSSHALTER SPEED RECORDER.

IT is a well recognized and undisputed fact that the presence of a speed recorder on locomotives and cars would be of great value to railways, and while many devices have been made for this purpose, few of them have been used to any great extent. One of the difficulties in the way has been to get an instrument which was at once reliable and reasonably cheap. In this country one company has succeeded in bringing a machine to a high degree of perfection and at the same time keeping the price down, which has resulted in its being quite largely used. In Europe several devices have been introduced, and one of them, known as the Hausshalter speed recorder, with such success that there are now nearly 1,700 of them in use. This instrument is contained in a circular iron casing about 12 inches in diameter, having a glass front. The details



MECHANISM OF THE HAUSSHALTER RECORDER.

of the construction of its important parts may be seen in the accompanying illustrations. In these illustrations Fig. 1 is a front view of the instrument, Fig. 2 a perpendicular section, Fig. 3 a horizontal section, Fig. 4 a detail of the principal parts, while Fig. 5 shows the manner in which the instrument is attached to a locomotive. By referring to the latter illustration it will be seen that the recorder is secured to the side of the locomotive cab by small bolts or screws. A shaft, A, extends from the instrument to a bracket beneath the running board. This bracket carries three bevel gears, the largest of which is mounted on the shaft, A, and the two smaller on a short shaft running at right angles thereto and carrying on its inner end a crank which is attached to the crank pin of one of the drivers so that as the driver revolves, the shaft, A, also revolves. The gear wheels are so connected that the shaft always revolves in one and the same direction regardless of that of the driver.

The shaft, A, is shown in each of the illustrations. A second shaft, B, shown in Figs. 2, 3 and 4, is revolved through an escapement by clockwork and makes a complete revolution every twelve seconds. The clockwork is actuated by a spring which is wound from the eccentric, D (Fig. 2), mounted on the shaft, A. As long as the shaft, A, is revolving, the spring is kept wound automatically, but a thumb nut is provided beneath the instrument by which it may be wound by hand when the engine is at rest. The instrument will run without winding for 50 minutes after the engine stops. The shaft, A, also carries a worm, D (Fig. 2), which meshes with a worm wheel, E (Fig. 4), on the shaft, F. On the opposite end of the shaft, F, there is a small gear wheel, G, the teeth of which engage with threads on a weight, C (Figs. 2 and 4). This weight is carried upon the shaft, B, and, although free to move up and down independently, must revolve with it. The threads on the weight do not extend throughout its entire circumference, but are cut out on one side, the cut being beneath the bottom of the threads and of sufficient width to allow the weight to pass freely by the small gear, G.

The operation of the machine is as follows: As the engine to which it is attached begins to move, the shaft, A, revolves, and in so doing winds the clock work, which sets in motion the shaft, B. Through the worm, D, worm wheel, E, and small gear, G, the latter acting on the threads thereon as on a rack, the weight, C, is gradually elevated during a period of twelve seconds. At the end of this period the weight, C, has reached a point where the space having no threads is opposite the gear, G, when the weight falls to its normal position. The height from which it falls depends entirely upon the speed at which the shaft, A, has been revolving, and as the speed of the shaft increases it follows that the height increases correspondingly. The recording mechanism of the instrument is arranged to puncture a strip of paper just before the weight drops, and the height of each puncture above the base line indicates the speed at which the engine was moving at the time the puncture was made.

The paper on which the record is made is carried on two rollers, HH (Fig. 3), and passes between two rollers, II. One of the rollers, I, is geared with the shaft, B, and the other roller is pressed against it by a spring. This gives the paper a motion constant with the shaft, B. A full size sample of the record produced is shown in Fig. 6. In this record the speed is shown by the irregular line of dots, and the space between the dots represents a period of twelve seconds. The lower of the solid horizontal lines represents the base line, and each line above represents 10 kilometers per hour, as marked. Each space between the dots in the first row beneath the base line represents one-half a kilometer; that in the second row beneath represents one and one-half minutes, and in each tenth space there is an additional dot representing 15 minutes. The space between the dots above the record represents one and one-half minutes.

The mechanism which makes these records, although simple, is very ingenious, but an explanation would involve additional engravings and a lengthy description not essential to an understanding of the main principles governing the action of the machine.

The speed, in addition to being recorded on the paper, is indicated by the pointer, J, shown in Fig. 1. This pointer is pivoted at K and carries a rack segment, L. The segment meshes with a rack, M, attached to the peg, N. The peg, N, is free to move up and down in a slot and is pushed up by the shoulder, O, on the weight, C, and down by the spiral, P (Fig. 2), which is a part of the weight, C. As the speed increases and the weight, C, rises, the hand is carried around with a gradual movement, being held when the weight drops by a spring, while the weight again rises. If the weight rises higher, as it revolves, the spiral, P, is carried above the pin, N, and the latter is pushed up by the shoulder, O, the hand moved around and a higher speed recorded. If the height attained by the weight, C, is not so great as formerly, the lower side of the spiral comes in contact with the upper side of the pin, pushes it down, turns the hand back and records a slower speed. It will thus be seen that the hand is adjusted every 12 seconds, but when wished a second pin is provided, by which adjustments are made every six seconds.

The manufacturers of this instrument make several very strong claims for it, one of the most important being that all movements are positive, affording no possibility of slip which shall give an erroneous record. All the main parts are operated by gears which must be broken before any slip can occur, and therefore as long as a record is made, it is correct. The connections are always made to a driver in order to check up the engineer if he slips his wheels, the amount of slip being determined by the dots showing each one-half kilometer run. This is deemed very important, as many reckless engineers shamefully abuse their engines in this respect. Another advantage in this instrument over others is the fact that time, as well as distance, is recorded. This gives exact information concerning the time consumed at stations, sidings, etc.

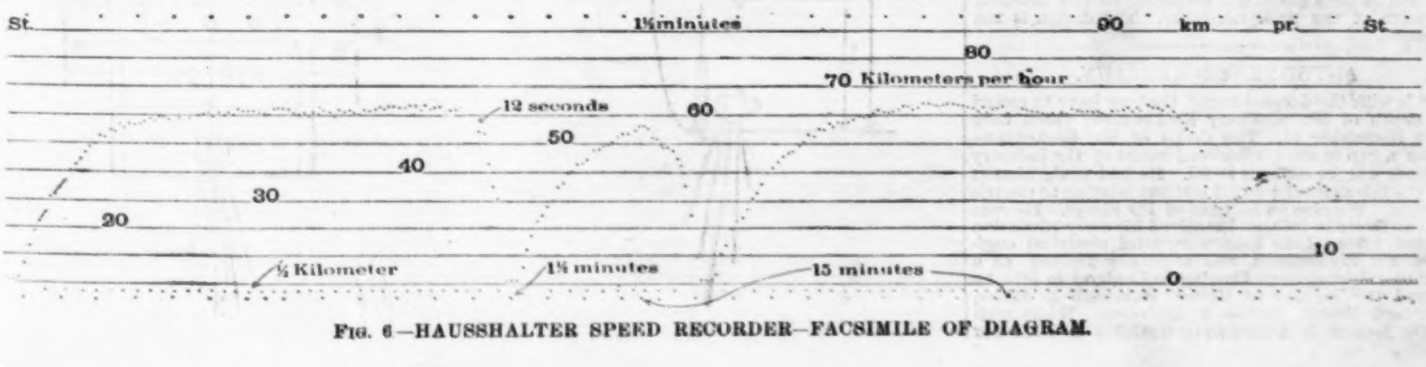


FIG. 6—HAUSSHALTER SPEED RECORDER—FACSIMILE OF DIAGRAM.

This is necessary to a complete record. Each instrument requires to be graduated for a given diameter of driver, but after it has been correctly fitted to an engine, the wear of the drivers is the only wear which affects the record. The movements of the parts of the instrument are all so slow that the wear is an unimportant consideration. The shaft, B, in making only one revolution in 12 seconds, would produce very little wear, and the shaft, A, is geared down so its motion is not rapid. As already stated, there are nearly 1,700 of these instruments now in use in Europe, and they have been so successful that the owners of the patents on the instrument are now making arrangements to have them made and placed on the market in this country. It is expected that they will be offered at a price so low as to remove all objection to their introduction on that score.—*Railway Review.*

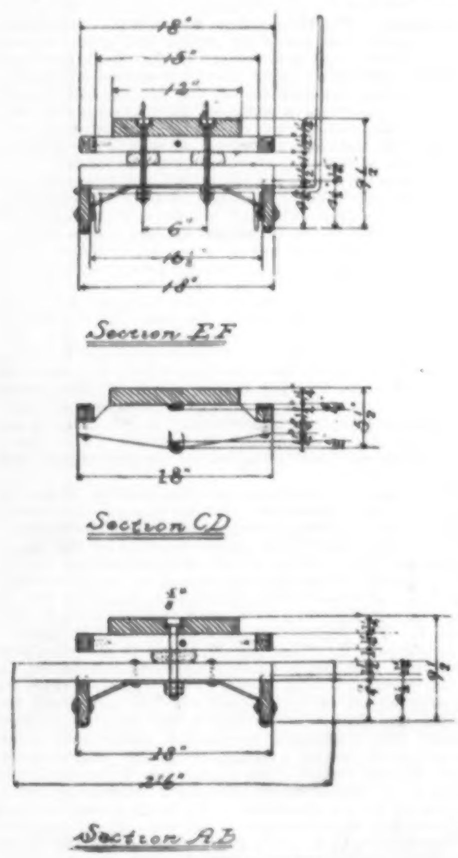
HOW TO BUILD A COASTING SLED.

By FRANCIS T. FREELAND, Aspen, Col.

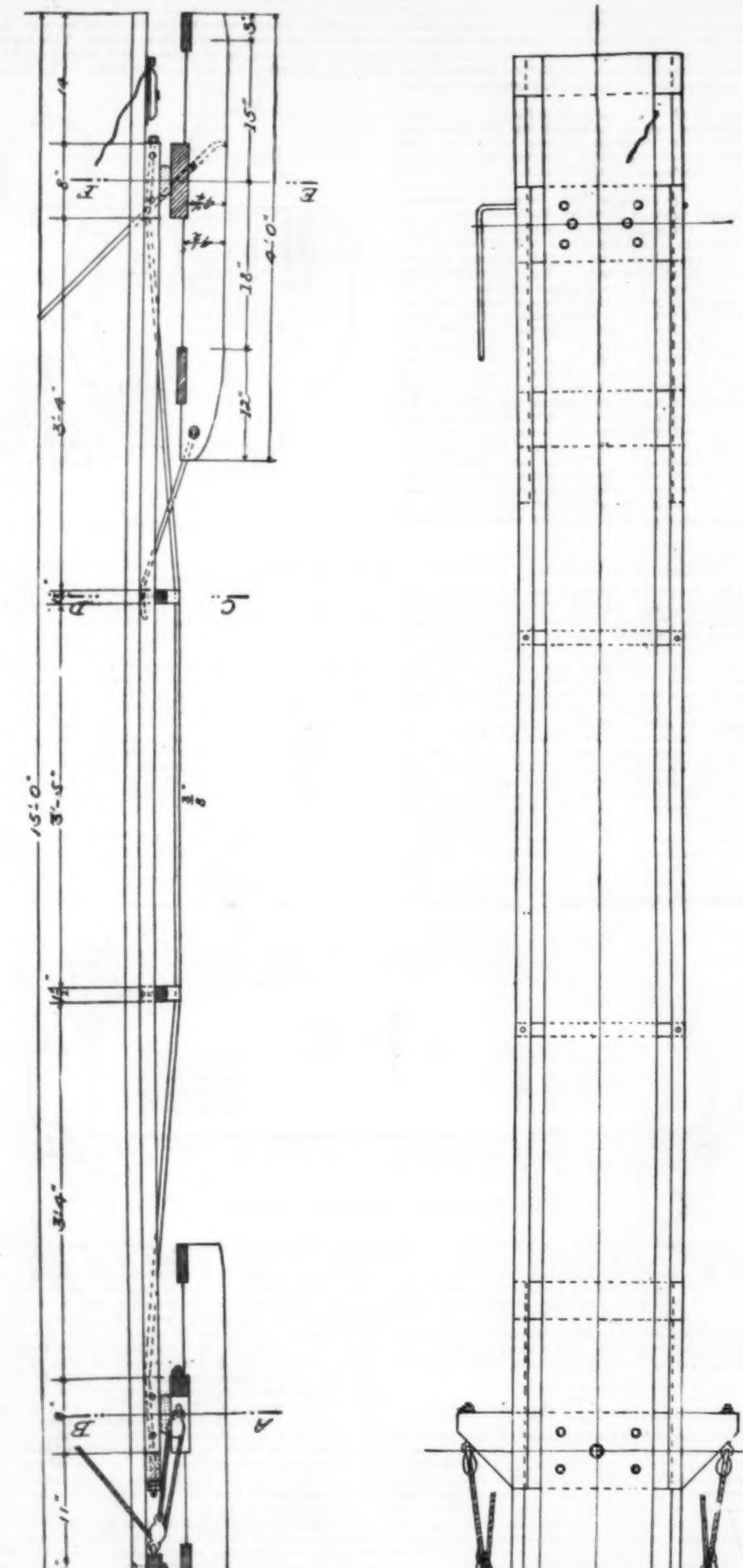
THE danger of coasting may be much lessened by a sled of good construction, provided with a powerful steering gear, brake, gong and lantern, and so designed that the seat is clear of all obstructions, enabling the passengers to roll or slide off, if a necessity arises.

The sled shown is 15 ft. over all, with seat of ash, 14 ft. × 12 × 1¼ in. It tracks 18 in. and stands but scant 10 in. from the ground. Rubber washers separate the seat from the bobs and take up the vibration. The truss rod acts as a spring on account of the rubber washer at one end. The bobs are of oak and lightly braced with riveted iron straps. The steering gear is new. It consists of double purchase blocks, working between the main cross-piece on the bob and the front foot-rest on the seat. When rocking sideways to counteract the centrifugal force developed in turning a corner, it will be seen that the rope is pulled in a perfectly natural direction. One man can steer this sled with ease with the whole load on. The runners should be narrow for speed on a hard surface, about ½ in., half-round steel, not flat nor oval, and be parallel and set to track in line. The foot rail allows the heel to clear the seat and yet not to jam in the slot. The seat is dressed smooth, but not upholstered. The V-shaped tongue of the back bob is riveted to the runners, and the point plays freely in the back truss-block under the seat. The truss-rod clears the front king-bolt. The rear queen-bolts have a little play. The lantern must be on springs, as in a bicycle, or it will go out. The sled is made as light as possible, about 150 lb., when the load is considered. Two or three men can easily pull it up hill, but for a large party a horse would be useful, as some may wish to ride back.

A good wagon maker and blacksmith can readily construct it, as there is no machine work on it. The cost will be from $25 to $35, according to the location, exclusive of the shelf hardware. The design is not patented.



COASTING SLED.



HOW TO BUILD A COASTING SLED.

ANTHONY RECKENZAUN.

IT is with the deepest regret that we have to record the death of Mr. Anthony Reckenzaun, which took place November 11. The death of Mr. Reckenzaun leaves a gap in the professional ranks of the industry which it will be difficult to fill. He had made himself the English authority on all matters relating to electric traction. We give an account of his career. He was born at Gratz in 1852, and received his early education in that town. Like most successful electrical engineers, Mr. Reckenzaun was originally trained as a mechanical engineer. Coming to England in 1872, he entered the employ of Messrs. Ravenhill & Miller, afterward Messrs. Easton & Anderson. While with Messrs. Easton & Anderson he qualified as a teacher

under the Science and Art Department, and established evening classes for the employes. Subsequently he attended lectures at the School of Mines and at Finsbury. Feeling a great interest in electrical matters, Mr. Reckenzaun made a thorough study of the apparatus at the Paris Exhibition in 1881, then joined the Faure Company, but soon after accepted the position of electrical engineer to the Electrical Power Storage Company. Here he turned his attention to traction, a branch of the industry with which his name has since been intimately connected. Storage batteries were also carefully studied, and their capabilities investigated. In fact, Mr. Reckenzaun perhaps did more than any one to show, by his practical work, and by various papers, the value of storage batteries in all kinds of electrical work. He spent a year or so in America successfully fighting the fight of such batteries. More recently he has been closely allied with the General Electric Company and with Messrs. Greenwood & Batley. Mr. Reckenzaun reached his acknowledged position as one of our foremost experts in batteries and traction because of the painstaking industry and skill with which he investigated every problem connected therewith. Some months since, the lung troubles to which he finally succumbed were felt to be serious; but although then seriously ill, he during the late summer visited America, hoping the change would prove beneficial, as well as desirous of continuing those business relations which he had on that side as well as on this side of the Atlantic. Unfortunately, the hoped-for improvement did not come, and on his return he gradually declined, though hopeful to almost the last. To most of us the loss of this prominent member of the industry means the loss of a personal friend whom we all esteemed, and who was as firm in his friendship as he was able and energetic in his occupation. As will be seen, Mr. Reckenzaun had been engaged in the industry from its rise in 1881, and throughout this period had made a reputation in his particular sphere second to none. His lectures on electric traction to the City Guilds formed the basis of a book on the subject, in which his great knowledge of the subject is fully shown. Recently his mortal remains were consigned to their resting-place in the presence of numerous friends.—*Electrical Engineer, London.*

THE WAR IN BRAZIL.

THE special correspondent of *The London Times*, who sends the accompanying map of Rio de Janeiro harbor, says that the condition of affairs is a curious anomaly. "There is no blockade of the city of Rio, owing to the action of the powers in protecting foreign shipping, and allowing it to carry on the ordinary commercial business of the port; for the same reason, the insurgents have not turned the guns of the fleet or those of Villegaignon on the town. To-day, there are two kings in Brentford—the legal President, or rather Vice-President, Marshal Floriano Peixoto is king of the land, and Admiral Custodio de Mello is king of the sea, or more correctly, of the harbor and the coast line, for the government forts of Santa Cruz, San Joao and Lage completely command the entrance of the harbor, and render the passage in and out a most difficult and dangerous undertaking for the insurgents. The key of the position is the possession of the forts at the entrance, and yet, for some reason difficult to fathom, the insurgents prefer to devote their energy and waste shot and shell in bombarding Nictheroy, the capital of the State of Rio de Janeiro. Matters cannot continue long as they now are. The two sides growl and bark at one another, but do not bite.

"Some 20,000 shots from different pieces of artillery have been fired and no decided advantage has been gained by either side. The insurgents have lost some 35 men killed, and the government has had about the same number of casualties to record at Nictheroy and Rio. The latter, however, sustained a further serious loss last month when the cruiser Republica rammed the transport Rio Janeiro, conveying troops to Santos. Eleven hundred men were on board the transport, and of these only 600 were saved by the Republica. It must not for a moment be forgotten that the city is completely at the mercy of Admiral Mello, and that at any moment he can lay it in ruins and thus force the resignation of Marshal Peixoto. Admiral Mello has in no way taken advantage of the fact that he has this power, but has met the representations made to him in a most friendly spirit, and has honorably adhered to his promises to the representatives of foreign powers."

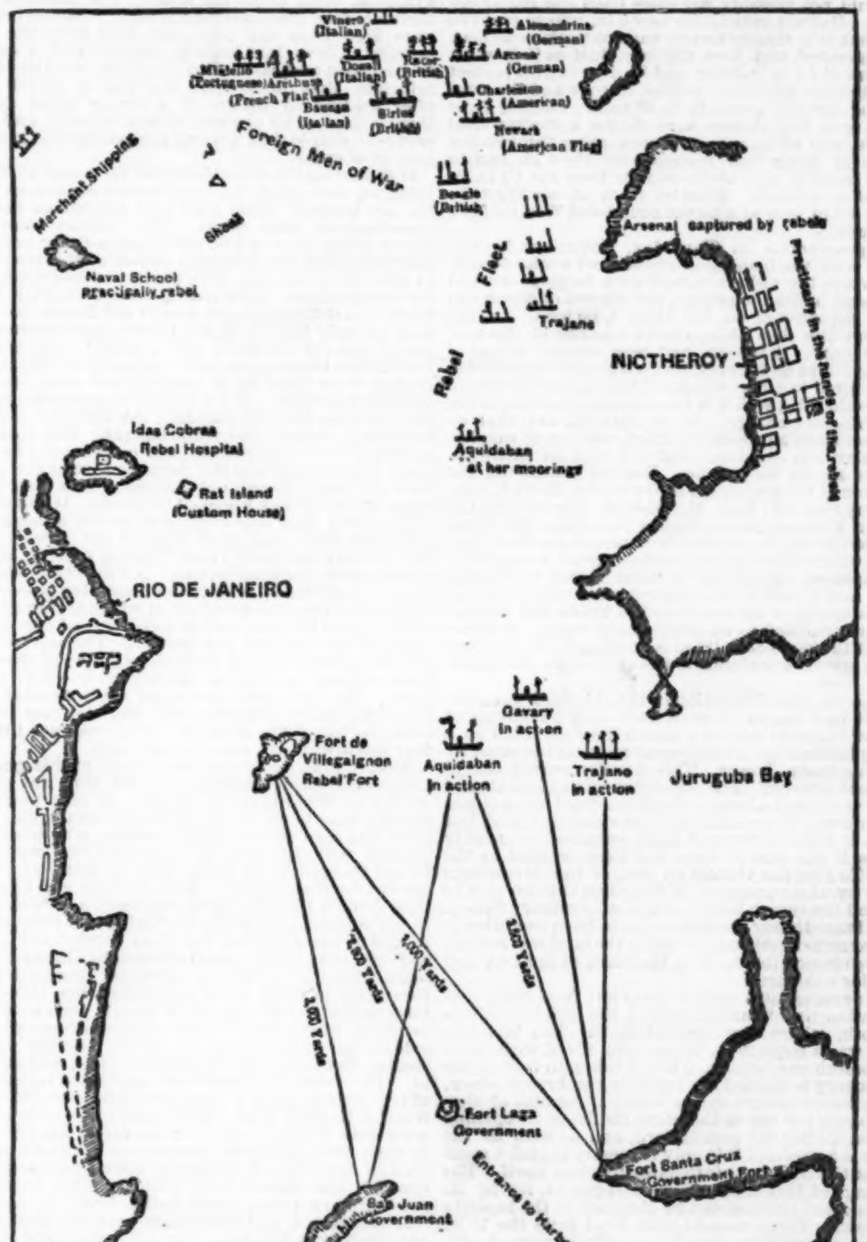
The correspondent proceeds to describe a visit paid by him to the Aquidaban, the flagship of Admiral Mello. "It was no easy matter," he says, "for the pains and penalties are many and various for any person caught in communication with the insurgents. The Aquidaban is not much the worse for all the heavy firing to which she has been exposed. Four shells have gone through the upper deck and burst between decks; another passed through the funnel, and the mizzenmast is half cut away; about a dozen shots have struck her on the sides without doing any damage. Both officers and men appeared cheery and contented. The admiral's secretary showed me the infernal machine that was sent from the shore for the purpose of disposing of the chief of the revolution. It consists of a thick volume entitled 'Consultos do Estado,' with the edges gummed together; the center was hollowed out and a pound weight of dynamite inserted. This was to be fired by a detonator fixed to the cover of the book, and would be exploded by the act of opening the volume. Happily the admiral had his suspicions of what the parcel contained, and so no harm was done. Admiral Mello received me in his usual courteous manner, and was anxious to supply me with all information I wished for. He stated emphatically that his action in the revolution had been taken after mature consideration of the consequences, and that he and his supporters had been forced into it as the only means of making an effectual protest against the military despotism and reckless financial policy that in his opinion characterized the administration of Marshal Peixoto. The admiral stated that the actual cause of matters coming to a head was the arbitrary manner adopted by Peixoto when he placed his veto on the bill providing that no vice-president was eligible for election to the presidency. The President exercised his right of veto on September 5, and on the morning of the 6th the insurrection was declared.

"Admiral Mello declares that the question of a restoration of the empire was never seriously mooted, but that if a majority in a new Congress favored such a movement it rested entirely with themselves to decide for or against it. He appears confident of success, but thinks he could gain his ends more expeditiously if he was recognized as a belligerent and enabled to use freely the rights that such a *status* would confer upon him. Not only does he claim that the provisional government of the United States of Brazil is firmly established at Desterro, the capital of Santa Catarina, but he also claims that the States of Rio Grande do Sul and Paraná are entirely with the insurgents. He states that Captain Lorenzo, the Provisional President, Lieutenant Mourao, Minister of Marine and Acting Minister of Foreign Affairs, and Major Annibal Cardoso, Minister of War and Acting Minister of Public Works and Justice, were all men who had been selected on account of their fitness for the posts they now occupy.

"If the insurgents win the day a general election will be held throughout the country, and it will be made a proviso that a civilian be elected as president. The insurgents are well supplied with ammunition, having seized all the naval warlike stores in the possession of the Brazilian government at the time the revolution broke out. Admiral Mello also stated that he considered he had a sufficiency of money for his purposes."

A telegram received from our correspondent on Wednesday, dispatched by him *via* Montevideo last Friday, shows that the situation has somewhat altered since the above letter was written. The insurgents have captured Fort Lage and are making progress in their movements in the north. Marshal Peixoto is making every preparation for the defense of the city. He states that he intends to fight to the last and that when his ships arrive he anticipates a victory. All business is suffering severely, and there is stagnation in every branch of trade. The financial position of the government has become difficult, the treasury being empty. A heavy artillery fire is kept up between the insurgent and the government batteries, and a good deal of injury has been inflicted. The members of the diplomatic corps consider that it is impossible for them to take further steps for the protection of the lives and property of the foreign residents, and the commanders of the foreign warships agree with them. Admiral de Mello is now inclined to bombard the city after giving 48 hours' notice.

Pernambuco has been declared to be in a stage of siege. This shows a spread in the rebel movement.



RIO HARBOR—DISPOSITION OF SHIPS AND FORTS.

INTERESTING ARTILLERY EXPERIMENTS AT ELSWICK.

THE great improvements recently made in artillery material by Sir W. G. Armstrong, Mitchell & Company, of the Elswick Works, Newcastle-on-Tyne, were the subject of a close inspection, extending over four days, by the representatives of several of the European powers, the United States and Japan. The inspecting officers were as follows: Colonel Petroff, Chief of the Staff, Bulgaria; Colonel Balabanoff, Director of Artillery, Bulgaria; Colonel Bojaroff, Bulgaria; and Captain Naidenoff, Bulgaria. Captain Henri Lansel, Swiss Attache; Captain Ismail Bey, Turkish Navy; Captain the Chevalier von Jedina, Austrian Naval Attache; Captain Angelesco, Roumanian Artillery; Captain Persico, Italian Attache; Mr. De Vere; Mr. Kunkler; Captain Yendo, Japanese Naval Attache; Lieutenant Yamanouchi, Japanese Navy; Mr. Yamaki and Mr. Matsuo, Japanese Naval Constructors; Captain Noff, Norwegian Artillery; Major Post, United States of America Attache; Captain Munos Hurtado, captain of the Chilean cruiser Blanco Encalada, built at Elswick; Commander Castilho, Brazilian Navy.

These officers arrived at Newcastle on Tuesday evening, November 7th. The 8th and 9th were devoted to an inspection of Elswick Works, and on the 10th and 11th a most elaborate programme of artillery firing was carried out at the range belonging to the company situated at Silloth, in Cumberland. On Wednesday, the 8th, the visitors were shown the methods of construction of various guns, including the system of winding wire or ribbon on the gun, known as the ribbon construction, and it may here be remarked that this construction, which was successfully employed first at Elswick, has lately come into prominence on account of the use of slow-burning powders such as cordite, which, bringing a greater strain on the front portion of the gun, require that portion to be given

extra strength. The visitors were also shown the testing of steel and bronze, and of the large spiral springs which are now so extensively used with the quick-firing ordnance. The cartridge factory created great interest for there the foreign officers saw all the processes, of drawing out cartridges in operation, but what created the greatest amount of interest was a large exhibit of modern quick-firing guns.

In the English navy the largest gun that deserves the name of quick-firing is a 6 in., but Elswick has just produced a very powerful 8 in. gun which may certainly be termed quick-firing, although no cartridge case is used with it, the obturation being performed by a modified De Bange obturator. To exhibit this gun a crew of five men were in attendance, and went through the drill. Some shot had had their driving bands turned off, and thus prepared, they were placed in the gun and pushed forward into the bore each time that the operation of loading was gone through. The drill, therefore, very accurately imitated actual practice, and yet the crew were able to go through the motions of firing three rounds in the very short interval of thirty seconds, and it should be observed that the present service 8 in. gun, which is a far less powerful weapon, could not possibly fire more than one round per minute. But not only is the new 8 in. gun so rapid in firing, but it is also extremely easy to work; one man trains, elevates, and fires the gun just as if it was a small gun of 4·7 in. caliber, and he does it with perfect ease, although the gun weighs 19 tons and the total revolving weight amounts to 33 tons. Passing from the 8 in. gun, the visitors were shown a similar trial with 6 in. and 4·7 in. guns, the crew going through the motions of firing four rounds from the 6 in. gun in twenty seconds, and seven rounds from the 4·7 in. in twenty-five seconds. Practice from an aiming tube out of a 4·7 in. gun at a target completed Wednesday's programme.

The programme on Thursday, November 9, commenced with the inspection of the steel works department, where the visitors were shown forgings worked under large hydraulic presses, the biggest of which can exert a pressure of no less than 4,500 tons. In the afternoon the first thing shown was one of the new torpedo guns. A trough had been erected in one of the long shops at Elswick, and a dummy torpedo was actually fired in this trough. The special feature of the torpedo tube, which is the outcome of a long series of experiments carried out at Elswick, are that by using cordite as a propellant a high velocity of wonderful regularity is obtained, and this with an entire absence of smoke or fouling. Having completed the inspection of the remainder of the works, Elswick shipyard was reached; here the visitors were shown the powerful Chilean cruiser Blanco Encalada, which has just been finished, and which is one of the fast cruisers of which Elswick has made so great a specialty. The Japanese cruiser the Yoshino is still in English waters, and it will be remembered that this vessel attained a speed of no less than 23·1 knots, the highest speed ever reached by an ocean-going vessel. Another vessel of the same class, that is to exceed all previous ships in speed, was shown to the visitors on the building slip.

By the time the inspection of the shipyard was completed it had begun to grow dark, and advantage of this was taken to exhibit a search light mounted on a steady platform, an arrangement recently invented by Mr. Beauchamp Tower. This novelty proved one of very great interest. The apparatus was placed aboard a small vessel and a beam of light was fixed on an object in the water. The vessel was then violently rolled, but in spite of this the beam of light remained as steadily fixed as if the search light had been secured to the jetty. To give the visitors an idea of the advantages gained by this apparatus, it was then thrown out of gear, and the search light became an ordinary fitting. It was immediately seen that in its then condition it had become perfectly useless while the boat was rolling, for it was impossible to keep the beam of light on any object for a moment.

On November 10 a special train left Newcastle central station at 7:30 and conveyed the party of officers to Silloth, where they arrived at 10. The first gun shown was a large 10 in. 30 ton gun, fitted with automatic breech mechanism. When this gun is fired the recoil energy is utilized for opening the breech screw, and for compressing a spring which is capable of closing it again; there is therefore no delay in opening the breech after the gun is fired, and as soon as the loading is completed it is only necessary to pull a small lever for the breech to automatically close itself. The advantage of this mechanism is apparent, for by its means a great increase can be obtained in the rapidity of loading. Three rounds were fired from the 10 in. gun, and the visitors were immensely impressed with the easy but rapid motions of the breech mechanism. A howitzer on a new mounting, designed for use in the field, was next shown. The peculiarities of this howitzer—which has a caliber of 4·7 in. and fires a shot weighing 40 lb.—is that the carriage automatically anchors itself, and the piece recoils within a jacket surrounding it. Several rounds were fired from this howitzer, used both for direct fire and for high-angle fire. The importance of such a weapon cannot be too much appreciated.

It is well known that some of the military powers of Europe have already adopted howitzers for field ordnance, and it is contended by Elswick that the howitzer exhibited has marked improvements on any previously constructed. A somewhat similar method of anchoring the carriage and absorbing the energy of recoil, by means of an hydraulic recoil press, was next shown, with a 15 pounder field gun. This field gun is also a quick-firing gun using cartridge cases, the breech of which is opened by a single motion of the lever. Several rounds of shrapnel and segment were fired at a target to show the accuracy of which the gun was capable, and to exhibit the anchoring and recoil arrangements. It was found that after the first round, which is used to set the anchor into the ground, the recoil only amounted to 8 in. Five rounds fired with shrapnel for rapidity, the gun requiring but little adjustment at each round, were completed in 53 seconds. The effect was exceedingly pretty, for scarcely did one shrapnel burst and scatter its bullets all round the target but that another followed its example, the target being 1,000 yards distant. Although this gun throws a shell weighing 15 lb., so well has the weight of every part been considered that the total of the whole equipment, with the limber loaded with thirty six rounds, only amounts to 32 cwt., and it must be recollected that a considerable addition has to be allowed for the cartridge cases.

Other field guns followed, showing various systems of brakes and of obturation. These included one gun of 90 mm. and one of 76 mm. A fifteen pounder mountain screw howitzer was also shown, and created as much interest as anything else on the programme. When the visitors were brought up to the gun it was lying in two pieces, just as it would have been taken off the backs of the mules which are supposed to carry it. In five minutes the gun was screwed together, and on its carriage, and ready for firing. Both shrapnel and segment shell were used, and the practice at a target 1,500 yards distant was greeted with loud applause. A 6 in. gun, on a light portable disappearing mounting, was shown in position behind a parapet which had been purposely erected. This mounting is specially designed for transport in the siege train, and it can readily be taken to pieces, so that the heaviest load does not exceed three tons, and yet it can be readily erected, the time required, if plenty of labor is available, being about ten hours. The erection could therefore take place during the night. Several rounds were fired from this gun, and each time the recoil brought it down into loading position with a wonderful precision and ease. The mounting is on the spring principle, that is to say, the gun is raised again after loading by means of a strong spiral spring; there is thus no air pressure system about it, and every part is so simple that it seems impossible that it should get out of order.

It should also be remarked that the range at Silloth being on loose sand, the most trying conditions possible are imposed upon guns and mountings that are experimented with there. The visitors were next shown firing from a 6 in. naval quick-firing gun on a new mounting, the principal object of this trial being to show the great ease with which the mounting could be manipulated. Five rounds were fired, each round being at a different range and at a different target, so that not only had the sights to be corrected after each round, but the elevation and a considerable training had also to be gone through. In spite of this the five rounds were fired in 60 seconds, and most excellent practice was made. A 4·7 in. gun on a pedestal mounting was then fired for rapidity, the shots all being directed at a target 1,000 yards distant. The total time of firing these five rounds was only twenty-two seconds, and so good was the practice that at the second shot the target, which only consisted of a cask with a flagstaff on it, was knocked to pieces. It should also be observed that this 4·7 in. gun was of a much more powerful type than those used in the British Navy, the velocity obtained from it being 2,500 ft., against 2,150 ft. from the English gun. A 4 in. 30 pounder gun was then shown. This gun and mounting possess several peculiarities, the principal of which is that the keys which guide the gun during recoil are on the sides instead of on the top and bottom. The advantage of the new position lies in rendering the top of the cradle unnecessary, and better protection is given to the keys. The gun and mounting are protected by a shield 4½ in. in thickness, and the sighting is done over the top of the shield in such a manner that the firer has always got an all-round view.

Aiming practice was carried on from this gun at a target 2,000 yards distant, and each shot was pitched within a few yards of the target. A new pattern of aiming tube to be used with these naval quick-firing guns was then shown to the visitors, who were much pleased with its extreme simplicity, and who entertained themselves for some time in firing at a target erected for the purpose. With the 6 in. gun an aiming tube firing a 1 lb. projectile was used, and with the 4·7 in. an aiming tube firing Martini-Henry ammunition. A trial of great interest was then carried out against a special steel plate manufactured by Elswick. The plate tried was of 0·223 in. thickness, designed for use for shields of small guns, especially when those guns form part of the armament of vessels, such as torpedo catchers, where weight is of great consideration. To exhibit the properties of the plate, another plate of similar thickness, but of ordinary steel, was also fired at. The trials the plates were subjected to consisted of ten rounds from a magazine rifle and 160 rounds from a Gatling gun. The dimensions of the plates were only 2 ft. by 1 ft. 6 in.; the range was 100 yards. In each case every shot was put on the plate, and although the firing was normal not a single bullet got through the special plate. On the other hand, with the ordinary plate, every bullet from the magazine rifle penetrated, and the stream from the Gatling gun practically cut it in two.

During the experiments a new naval range finder, invented by Messrs. Barr & Stroud, was exhibited, and during the intervals between the firings the visitors amused themselves by taking the distances of all the surrounding objects. The ease with which the instrument was understood and manipulated was most remarkable, and the visitors were fairly astounded by the accuracy of these readings.—*The Engineer, London.*

FERMENTATION.

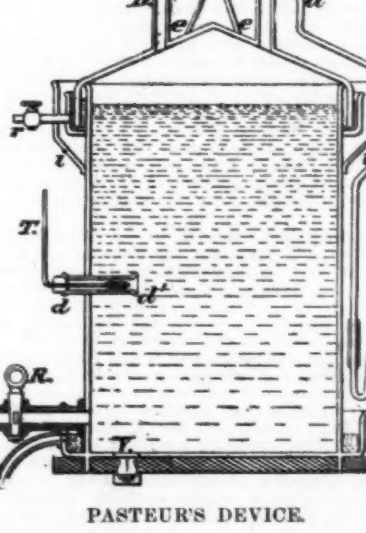
By C. C. STAUFFER.

FERMENTATION is an effect concomitant with a large number of biological processes. The acts of mastication and digestion, the germination of seeds, the formation of cheese, the decay of all tissues, whether living or dead, the formation of wine, beer and vinegar, are some of the processes which are due, in whole or in part, to the growth of micro-organisms, which may be broadly defined as ferments. There is, at first sight, a wide difference between the dreaded cholera bacillus and the familiar yeast germ of all brewing establishments, but they are both minute forms of life whose modes of existence and of propagation are, in many respects, similar. This article, however, has to do with the ferments used in the production of wine and beer and the apparatus by means of which they can most readily be made to produce a desired result.

In the ordinary mode of making beer, two ferments, or rather ferments of two kinds, are employed. The first of these are the soluble or diastatic ferments or enzymes, which serve to convert the raw grain into fermentable substances during the process of malting, and are characterized as four, viz., diastase, invertase, peptase and cytase. These all have distinctive functions, the diastase acting upon the starch of the grain to convert it into the sugar called maltose, the invertase having the power of converting any cane sugar present, which is not fermentable, into dextrose and levulose which are fermentable, the peptase serving to convert the albuminoids into peptones, leucin and tyrosin, and the cytase serving to bring about the dissolution of the walls of the starch cells and thus render the starch more accessible to the diastase.

The effect of the soluble ferments is, however, simply to prepare the raw material for the action of the true ferments or yeasts, which belong to another class. The ferments which are apt to exert an influence upon the wort during the process of fermentation are of three genera, viz., the saccharomycetes, or yeasts, the schizomycetes, or bacteria, and the hyphomycetes, or moulds. Among the bacteria is included the butyric ferment which is the dreaded cause of the so-called "sickness" in beer. As might be imagined, both the bacteria and the moulds are injurious and are to be avoided as much as possible. The patents referred to below have special reference to the exclusion of all harmful organisms and the encouragement of the growth of the true yeasts. The nature of the resulting beverage depends mainly upon two factors, the material employed and the character of the yeast with which it is set. These are, of course, more or less modified by conditions of temperature and pressure. It is necessary to consider yeast as a plant of which there are a number of species and capable, when placed in a suitable environment, of growth and reproduction with a concomitant breaking up of the sugar and albuminoids present into ethyl and other alcohols and carbon dioxide. Of the several species of yeast, the *Saccharomyces cerevisiæ* is the one chiefly employed in the production of malt liquors and the *Saccharomyces ellipsoideus* is the main ferment of fruit juices and wines. Besides the ones mentioned, there are a number of others which are apt to be present to some extent, some of which are known as wild yeasts. The wild yeasts are injurious equally with the bacteria and moulds. The effect of all these is the production of bitter, acid or otherwise badly tasting substances. As a rule, however, the conditions of temperature and environment which are favorable to the thorough and rapid production of yeast of one kind hinder the production of others. Hence these injurious bodies lie dormant until a suitable time and temperature occur. This fact is of importance when we remember that commercial yeast is a mixture of several saccharomycetes, the normal yeast (*cerevisiæ*), of course, largely predominating. Other varieties are abundant, however, and it is upon the presence and character of some of these that the differences in flavor of fermented liquors, in a large measure, depend. The brewer's difficulty lies generally with the wild yeasts and the bacteria present.

The nature and essential characteristics of yeast were first made clear by Pasteur, and his researches have been followed up and supplemented by many other savants, among whom Dr. E. Chr. Hansen, of Denmark, is one of the foremost. Pasteur was the first to point out the relation between pure yeast and good products, and the practical application of his conclusions in many breweries throughout Europe led to a general and rapid improvement in the character of their products. One means employed by him for the isolation of pure yeast germs and the subsequent propagation of yeast of a definite character is shown in the accompanying figure, which is taken from his United States patent, No. 141,072.



PASTEUR'S DEVICE.

He takes impure yeast and causes it to act on a solution of sugar candy in pure water. When the fermentation is terminated, he decants the fermented liquid and adds a fresh quantity of sugared water on the top of the yeast deposit. This operation is repeated two or three times, more or less, according to circumstances. He then takes a shallow porcelain dish, first dipping it in boiling water, and puts in it a little beer wort which has been recently boiled or preserved by the Appert process. He then dilutes a little of the yeast deposit of the above described fermentation in the wort, and covers it with a glass plate. The yeast, which has become more or less exhausted by its action on the sugared water, will then rise and rapidly revive, purified of all germs of disease.

This treatment may be repeated by diluting a little of the yeast deposited at the bottom of the first dish in some fresh wort.

The degree of purity of the yeast may be ascertained with the aid of a microscope, which will indicate the presence of the germs, and show whether, by means of the yeast, a beer may be produced which shall not vary in condition at any temperature.

The apparatus consists of a cylindrical vessel, closed by a cover, the rim of which dips into a water trough around the top of the vessel, provided with a cock, *r*. The beer wort, properly so called, or other wort used in beer making, is first boiled in the copper, and then poured into the cylinder, which is completely filled, and the cover put on. Then, by means of a rubber tube, *c d*, the metal pipe, *a c*, opening into a stoppered pipe rising from the cover, is connected with the tube, *d e f g*. Boiling water is then poured on the cover and on the pipes rising therefrom, which fills the trough, the overflow passing into a gutter, *i i*, from which the water escapes through a slit or a number of small holes in the bottom, and is collected in another gutter at the bottom of the cylinder, provided with a discharge pipe, M.

T is a bent thermometer, for indicating the temperature of the wort, the bulb of which is protected by a perforated guard, *d d'*. R V are cocks or apertures for discharging the liquid and sediment from the cylinder.

The cylinder thus filled is allowed to cool by contact of the external air, afterward assisted, if necessary, by cold water introduced at pipe E on the cover, which passes through apertures, *e e*, and trickles down over the cylinder. Air enters the long tube, *g e f d e a*. The yeast is then introduced through the pipe, D, which is immediately closed, the carbonic acid produced during the fermentation passing off at tube *f g*.

A tube similar to *a e d e f g* may be adapted to pipe, D, of a different length, if desired, for the escape of the carbonic acid gas, while a limited quantity of air is admitted by the other tube.

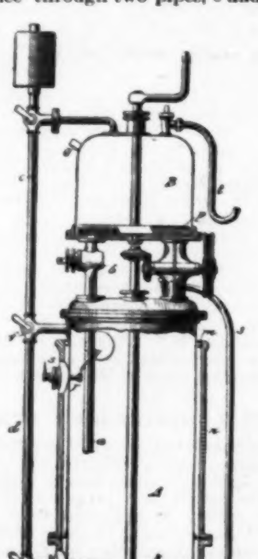
The wort may be readily cooled in presence of carbonic acid gas by introducing the latter beneath the cover during the cooling.

The tube, *f g*, may terminate by a loose plug of asbestos or cotton, or by a metal tube heated during the admission of the air. A drop of liquid in bend *g* will serve to indicate the movements of the gases.

It should be borne in mind, however, that several species of yeast are so closely allied to each other and so nearly of the same form that they can only be distinguished by a careful study of their effects. The method just described would not therefore suffice in all cases.

Another later and somewhat improved apparatus is that shown in the following illustration, which is taken from the United States patent to Jorgensen & Bergh, No. 467,993. This device is especially designed for use in carrying out some of Hansen's ideas. The operation is as follows:

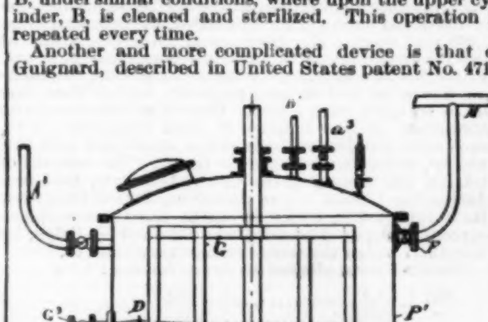
Sterilized air can be conducted through an air filter, C, and thence through two pipes, *c* and *d*, and three



A. JORGENSEN & A. BERGH, 1892.

cocks, *e*, *f*, and *g*, to both cylinders. The wort is preferably introduced in the sterilized state into the lower cylinder, A, directly from the brewery, or it may be sterilized in the same cylinder by admitting steam to a chamber, *i*, at the lower part of a casing which surrounds the aforesaid cylinders. After the desired quantity of wort has been admitted the air is introduced in a suitable manner. For this purpose the third or lower of the above-mentioned cocks, *g*, communicates with a pipe, *k*, which is arranged in the lower cylinder at a short distance from the bottom of the same, this pipe being closed at one end and provided with small holes at the inner and outer sides. The three cocks, *e*, *f*, and *g*, are so placed that the air is forced through the filter, C, directly into the said pipe, *k*, from which it issues on both sides. At the same time an agitator, *l*, which is preferably made of helical form and arranged as closely as possible to the bottom and sides of the lower cylinder, A, is caused to rotate for the purpose of stirring the wort. The cooling is effected by causing cold water to pass from an annular pipe, *m*, surrounding the upper part of the said cylinder along the outer periphery of the latter, or to circulate either in the chamber, *n*, at the lower part of the latter casing round the cylinder or in the entire casing. A quantity of the aerated and cooled wort is forced by air pressure into the upper cylinder, B, which is sterilized by steam or in any other suitable manner. Absolutely pure yeast produced in the laboratory is introduced through a pipe, *o*, into the upper cylinder and is intimately mixed with the wort by means of the helical agitator, *p*, arranged at the bottom of this cylinder. In order to enable the quantity of wort which has been introduced into the lower cylinder and forced upward into the upper cylinder to be indicated without the use of a gauge glass, a float, *r*, is connected by means of an arm to a spindle, *s*, which extends to the outside of the cylinder and carries a hand which indicates the level of the liquid in the said cylinder, A. When the yeast has been intimately mixed with the wort in the upper cylinder, B, the charged wort can be caused to pass through the above mentioned cock, *b*, and pipe, *a*, back to the lower cylinder, A, either at once or after it has been allowed to ferment in the upper cylinder. After the wort contained in the lower cylinder, A, has likewise been started and the yeast has been properly mixed with the same, a definite quantity is forced into the upper cylinder, B. The charged wort and both cylinders must be kept at a temperature adapted for the continuation of fermentation. As this apparatus has for its object to produce pure yeast for use on a large scale, it is a matter of course that this yeast can be removed either when the fermentation has reached its highest stage or after the yeast formed has fallen to the bottom of the cylinder. In the former case the entire mass is stirred on the third or fourth day of the fermentation by means of the above mentioned agitator, *l*, and is then removed and added to the wort in a large fermenting vessel. In the latter case the beer standing over the yeast is let off through the pipe, *k*, near the bottom of the cylinder and the lower of the three cocks, *g*, as the said pipe, *k*, occupies such a position that enough beer will remain in the cylinder to keep the sediment sufficiently liquid for removal. The superfluous air and the carbonic acid produced escape through two bent pipes, *t* and *u*, connected with the upper and lower cylinder. In either of these cases a sufficient quantity of fermenting wort must be forced beforehand into the upper cylinder, B, for enabling a fresh fermentation to be subsequently commenced therewith in the lower cylinder, A. When the yeast has been removed, the lower cylinder, A, is cleaned and sterilized. The wort is introduced in the manner described and treated with the yeast formed in the upper cylinder, B, under similar conditions, whereupon the upper cylinder, B, is cleaned and sterilized. This operation is repeated every time.

Another and more complicated device is that of Guignard, described in United States patent No. 471,-

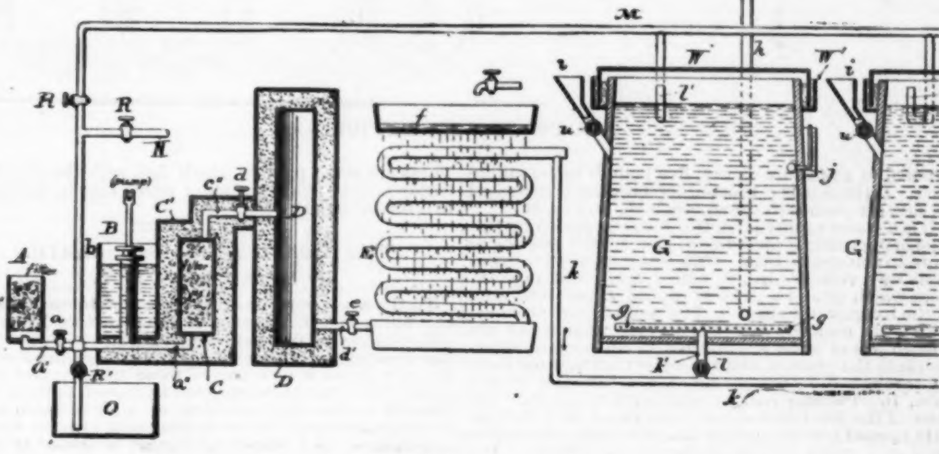


G. GUIGNARD'S DEVICE.

335. This has for its objects the sterilization and cooling of the wort, the introduction of pure yeast, the perfect sterilization of the air necessary to the growth of the yeast and the introduction of the pure yeast growth into sterilized flasks without exposure to contagion. The fermenting vat which he employs is here shown in section.

All the cocks being turned on, the apparatus is sterilized by a current of superheated steam, which is led through the cock, E², during about twenty minutes at a temperature of about 120° Centigrade after the exit of all the air. Thereupon the apparatus is cooled and the steam inlet, E², is closed, and the cock in pipe, A', is opened to admit the worts from the cooler. During the fermentation the steam inlet, E², is closed and cock, E³, is opened to admit sterilized air, which is forced under pressure through the mass in the vat, thereby greatly increasing and expediting the production of the yeast. B' is an escape cock for the air or steam, and is closed when the fermentation begins, at which time the cock, F, is opened, and through it the carbonic acid and water generated in the vat pass into a general piping, M, the end of which may be submerged in an antiseptic liquor—such, for example, as a solution of corrosive sublimate. By this means unsterilized air is prevented from flowing back. The cock, a^3, is used to control the admission of sterilized air at the top of the vat to aid in the expulsion of the matters therein by the exit pipe at the bottom controlled by cock, E². G is an agitator.

The accompanying cut is taken from the patent to Lawton, No. 468,809. The apparatus is used for the purpose of preventing the introduction into the wort of deleterious ferments and bacteria from the air while it is subjected to the proper yeast ferment. This result is effected in a rather unique manner. The hot wort is run into the tuns, G, through funnel, *i*, or pipe, *h*, and the covers, *w*, put on while the liquid is still hot and sealed by the antiseptic liquid in the trough, W'.



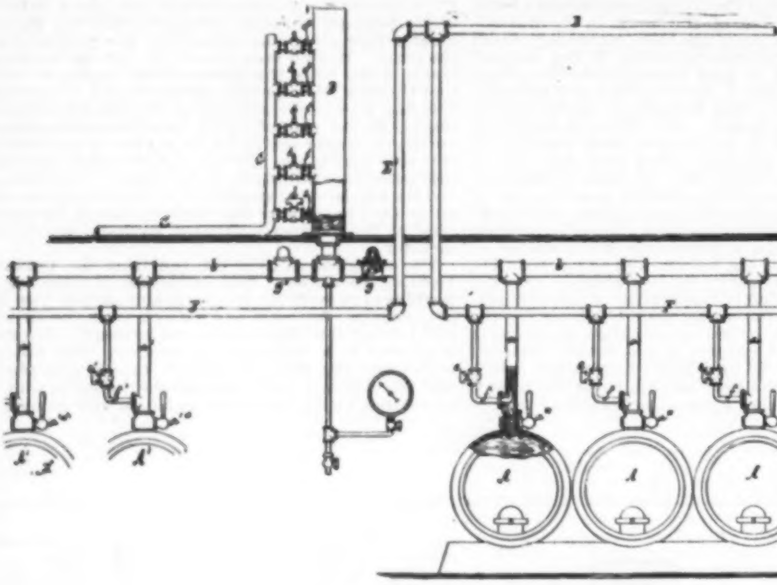
C. F. LAWTON'S DEVICE.

Air is then forced by pump, B, through filters, A and C, reservoir, D, and cooling coil, E. The filter, A, removes the mechanical impurities from the air. The filter, C, is packed with sand or compressed asbestos, and this filter, as well as reservoir, D, are surrounded by a non-conducting packing or covering. The air being drawn in by the pump more rapidly than it can escape into the fermenting tuns through the cocks, *l*, which are opened but a little way, is condensed and heated in filter, C, and chamber, D, to a temperature sufficiently high to kill all the germs which it may contain. It is subsequently cooled at E. This device may be used to cool the wort, as well as to supply the air requisite for fermentation. The carbon dioxide produced by the fermentation is drawn off at O. The pipe, N, may be used to charge the liquid with another gas, if desired.

The foregoing patents have dealt mainly with the purification of yeast, wort or air. There are, however, other conditions which sometimes maintain and which may modify the result to some extent. The alteration of atmospheric pressure is one of these. The first suggestion of this kind to be set forth in any patent is that disclosed in a patent to Sheridan as early as 1837 (No. 245). In this it is said that the pressure is maintained during fermentation at from 15 to 20 inches of mercury, the latter pressure being used in the last 24 hours of the process. The patentee asserts that this diminution of pressure prevents the development of the acetous ferment, but it is somewhat doubtful whether his assertion can be maintained. It is probable that the development of this ferment is prevented in the usual way—that is, by keeping down the temperature. In British patent, No. 4,746, of 1890, it is asserted that "in highly rarefied spaces the efficacy of yeast as an exciter of fermentation is far more energetic and productive than in non-rarefied spaces, and the quantity of yeast necessary for a given purpose is greatly reduced. . . . In the case of bakers' goods, about 50 per cent. less yeast than is usual may be employed," if the pressure be greatly diminished. The two cases last referred to are to be contrasted with that of Lawton's, alluded to above, in whose apparatus the pressure must always be, to a slight extent, at least, greater than that of the atmosphere. This is also true of the apparatus used by Jorgensen and Bergh, as well as of that used by Guignard. The device of Pfaudler, patent No. 293,909, illustrated is one in which it is especially intended that the pressure shall be greater than that of the atmosphere. The patentee has, however, failed to point out any advantage to be derived from this increase of pressure during fermentation.

In this drawing the letters A A A represent a series of fermenting vessels or casks, which are connected by pipes, *a a a* (which I term the "hydrostatic" pipes), to a pipe, *b*, which extends from the bottom of a vertical tube, B. This tube is filled with water or other liquid, and it is provided with a series of nozzles, *c c' c² c³ c⁴*, which communicate with a common discharge pipe, C. Each of the nozzles is provided with a stop cock, *d*, and if the nozzle, *c*, is opened the liquid in the tube, B, sinks down to the level of this nozzle; but if this nozzle is closed and the second nozzle, *c'*, is

opened, the liquid in the tube, B, sinks down to the level of this second nozzle, c', and so on. If the casks, A A A, are filled with beer or other fermentable liquid, and the stop cocks, a^2, in the hydrostatic pipes, a a a, are opened, the liquid in the casks is exposed to the pressure of a column of liquid, the height of which can be regulated by means of the nozzles, c c' c² c³ c⁴. I place the tube, B, at such a level above the casks, A A A, that if the nozzle, c, is open the liquid in the casks is

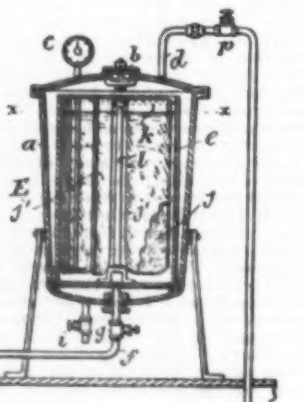


C. PFAUDLER'S DEVICE.

exposed to a pressure of, say, five pounds to the square inch. If the nozzle c' is open, the pressure is increased to, say, six pounds to the square inch, and so on.

D is a water supply pipe, the water supplied by this pipe being under a pressure of, say, fifteen pounds or more to the square inch. This water supply pipe connects by a vertical pipe, E, with a horizontal pipe, F, from which extend a series of spouts, f, one into each of the hydrostatic pipes, a. The spouts, f, are provided with stop cocks, e, and when these stop cocks are opened jets of water are injected in an upward direction into the pipes, a, and the water thus injected flows off through the open nozzle (c, for instance) in the tube, B. The stop cocks, e, also serve to regulate the force of the jets injected into the pipes, a, and they are only opened just far enough to enable said jets to produce an upward current of the requisite force. The liquid in all the casks, therefore, is held under a hydrostatic pressure of, say, five pounds to the square inch if the nozzle, c, is open, or six pounds to the square inch if the nozzle, c', is open, and so on, as will be readily understood from the foregoing description. The barm, as it forms from the fermenting mass contained in the casks, A A A, enters the hydrostatic pipes, a a a, and by the upward currents produced by the jets injected through the spouts, f, such barm is carried off into the tube, B, when it flows off through the open nozzle, c or c', as the case may be, and through the discharge pipe C.

Fermentation under pressure is also a feature of the Gotter patent shown below.



H. GOTTER'S DEVICE.

The fermenting vessel, E, is illustrated as containing spun glass, j, as the material immersed in the wine while undergoing fermentation. In order that this spun glass shall be distributed in all parts of the vat, it is placed in bags, j', of suitable material, which are suspended from the rods, k, radiating from a central standard, l. Obviously, this supporting mechanism may be varied—for instance, silver wire may be used—the object in view being to distribute the substance, whatever it may be, in various parts of the vat.

It is obvious that the more evenly and thoroughly the yeast is maintained in a state of distribution throughout the liquid, the more rapid and complete the fermentation will be. The maintenance of this state of distribution is the design of a patent to Gotter, No. 443,190. He fills the fermenting vessel, E, with spun glass in sheets and with the barm or yeast thoroughly distributed through these sheets. This keeps the yeast from rising to the top or settling to the bottom of the wort, as in ordinary top or bottom fermentation.

Other means have been used by other patentees, as paper, cotton, flax, hemp, chopped hay, fiber, pulp, sawdust, fruit skins, etc., by Reihlen (patent No. 301,006), and animal fiber, especially wool, by Meyer (patent No. 467,308), both of whom state that peculiar advantages result from the use of their respective materials.

The foregoing patents have been selected with especial reference to their relation with the mechanical features involved in the process of fermentation. There are many patents which deal with the chemical features of the subject, some of which may be discussed in a future article.

THE DENSITY OF THE EARTH.

By HENRY WURTZ, Ph.D.

To the five figures that we have heretofore had for the mean specific gravity of the planet we live upon—the outcome of five distinct sets of experiments—there has been recently added a sixth, by Alphonse Berget. His new figure is now one of three which agree even better than should be expected from such delicate and difficult work as the weighing of a globe 24,000 miles in circumference. Yet we appear now to have figures inspiring much confidence. Berget's method was by measuring the relative attraction upon a "hydrogen gravimeter" of a lake of 100 acres surface, in the province of Luxemburg, Belgium, at its highest and lowest points, varying in level about a foot and a half. The mass of water was, therefore, 6,534,000 cubic feet; and weighed 2,721,411 tons. His earth density determination was 5·41.

One method used by Maskelyne at Mt. Schiehallion, near the Tay, in Perthshire, Scotland—also by Col. James, at Arthur's Seat, near Edinburgh—was based on the divergence from the exact radial direction of a plumb line produced by the attraction of the mountain. It is therefore subject to errors in the determination of the mass of the mountain. Col. James' figures led to a density = 5·316, the smallest of the six here discussed. Professor Airy, the British Astronomer Royal, made many attempts, at first unsuccessful, to obtain figures in another way, by establishing duplicate pendulums, at the surfaces and bottoms of deep coal mines. He succeeded, in 1854, at a mine 1,260 feet deep. He here found an acceleration of the lower pendulum of but 2¼ seconds per 24 hours. From this he computed for the density 6·565, the highest figure on record, and probably higher than the truth by more than a unit. Cavendish measured the attraction of two spheres of lead weighing 174 lb. each upon two leaden balls of one hundredth part this weight, suspended in a torsion frame. The amount of torsion was measured through a telescope, first producing the torsion in one direction, then in the other. He obtained 5·48, which is one of the three best concurrent figures. The third was obtained by Reich, by a method which the writer cannot now refer to.

The six figures alluded to are as follows:

No. 1.	Col. James	5·316	
" 2.	Berget	5·41	Mean of 3 = 5·443
" 3.	Cavendish	5·438	
" 4.	Reich	5·48	
" 5.	Baily	5·66	
" 6.	Prof. Airy	6·565	
	Mean of all	= 5·645	
	Mean of 1 to 5	= 5·461	

The method of Cavendish is, to judge from these few figures, the most likely to lead in the path of success. Instead of six, however, we ought to have a hundred determinations made under all possible variations of the conditions.

No one will doubt, however, that the three figures, Nos. 2, 3 and 4, giving us the mean 5·44, must be approximations to the true mean density of our globe. It follows that the average density of all the materials of the sixteen miles of the earth's crust that we know geologically is less than half the mean density.

Moreover, the average of the materials thrown out by volcanoes—believed by geologists generally to come from several hundred (some say 800, others 1,000) miles below the surface—is also less than half the above mean. The conclusion then follows that the average mass of the globe, below the sphere of volcanic action, must be very greatly heavier than the mean, and we shall not exaggerate in assuming that it may be higher than 10 (water being =1). For if we compute the volumes of spheres of 8,000 miles and 6,000 miles in diameter, according to Hennessy's mathematical investigations, we find the former to be 268,083,200,000 cubic miles, while the latter is only 113,097,600,000 cubic miles, much less than half the whole. Even if we take off a shell of but 800 miles, as Mr. Hopkins has mathematically deduced for the thickness of the crust, from the precession of the equinoxes—which gives us an inner sphere of 6,400 miles in diameter—we find for this latter the volume 137,258,598,400 cubic miles, which is little more than half the whole volume of the earth. The writer believes, therefore, that we are entirely justified in assuming a density even greater than ten times the weight of water for this inner nucleus of the earth, below the solid stony crust, of the deeper portions of which volcanic eruptions furnish us samples.

This slight discussion has now led us directly to a stupendous question. What is it that we have in this inner half of our globe? Geologists of the highest class are apparently mainly agreeing of late years in the view that this internal nucleus must be a *solid* mass and not liquefied by heat, as formerly imagined. We get no decisive solution of this great question from the materials we find in the outer portions of the crust or from what volcanoes send us of the inner portions. The loose assumption has been long since made, and is often reiterated, that this problem is fully solved by an absence of oxygen in this internal nucleus, and that the *metals* found in the outer crust being, therefore, in their elemental state, are, of course, heavier than on the surface.

This assumption abjectly fails, on examination, to unriddle the problem. What do we find in the outer crust accessible to us everywhere and in the samples of the inner crust sent to us by volcanoes? In the first place the latter is generally quite as highly oxidized as the outer crust. But this is not the main point. At least fifty per cent. both of the outer crust and of the volcanic matters erupted is silica, the specific gravity of the elemental base of which, *silicon*, in its densest crystalline (adamantoid) form is only 2·48. The next most abundant metal, probably 8 or 10 per cent. of the whole, is *aluminum*, whose greatest solid density is 2·807. Next to these in abundance, we have *potassium* and *sodium*, both lighter than water; *magnesium* (heaviest form), 2·14; *calcium*, 2·584; *carbon* (the heaviest, diamond), 3·55; *sulphur* (heaviest), 2·086; and *hydrogen* (liquefied), 0·33. Those already mentioned (with oxygen, which alone constitutes half the weight of the solids of the crust, including the lavas) virtually make up the bulk of the said crust—all the heavier metals together summing up, in all probability, not more than one per cent. Where, then, is the rationality or the justification for the assumption that this nucleus, below the volcanic shell, is made up of heavy metals? The most abundant of these heavy metals, *iron* and *copper*, have the maximum densities respectively of about 8·14 and 8·96 (see SCIENTIFIC AMERICAN SUPPLEMENT, No. 938, pp. 14996–7). As for *lead*—the only common metal that is heavy enough to satisfy the conditions of the problem, being as heavy as 11·5, when compressed—we can scarcely admit so monstrous a supposition as a sphere of lead 6,400 miles in diameter inside our planet. As for *silver*—whose maximum known density is 11·1—it is quite as violent a hypothesis to assume that our globe carries so much of that in its bowels. Were it so, there ought to have been, among the multitude of volcanoes, some one, say like Krakatoa, whose voice is heard a thousand miles or more, obliging enough to throw up for us a million tons or so of it. *Gold, platinum, iridium*, and other very heavy metals it is scarcely worth while to consider in this connection. They probably never occur among volcanic products. Briefly to sum up; our conclusion must be that in the central parts of the planet earth there is a mystery which, so far as we can yet see, must remain altogether inscrutable to mortal man, whose mission it is nevertheless to "replenish the earth, and *subdue* it." This was the first command ment given to him by his Creator, as found in the first chapter of the first book of Holy Writ.

THE LUMINIFEROUS ETHER.

SIR G. C. STOKES has recently published some interesting remarks upon a subject about which, he says, the study of light has caused him to think a good deal—namely, the nature and properties of the so-called luminiferous ether. It appeared from his discourse that Sir G. C. Stokes is one of those philosophers who regard the luminiferous ether as a conception of the scientific mind put forward as supplying the obvious need of something for light and gravity to act through or by, thereby avoiding the alternative of supposing these phenomena to be the results of action at a distance. Newton himself scouted the idea of action at a distance as too absurd for any "man who has in philosophical matters a competent faculty of thinking" to entertain. He accepted the existence of an "agent" between bodies affected by gravity; but what this necessary agent might be he was content to leave to the consideration of others. Now, as Sir G. C. Stokes points out, modern science has shifted into the background the difficulty of defining the nature of this unknown agency, by calling it the "ether," which term is in this connection no more than the mathematician's eternal x written in five letters. All that is certainly known about it is negative; while of many aspects from which the conception can be regarded it is impossible to say anything either positive or negative. Granting the physicist his ether, is this the same thing that propagates light and gravity? Sir G. C. Stokes confesses that "we do not know." We cannot conceive of space as other than infinite—is the ether likewise infinite? Again we do not know. Does the ether gravitate toward what we call ponderable matter? This is another question to which no positive scientific answer can be given; and the same remark applies to the question as to whether the ether consists of ultimate molecules, such as those of which there is strong reason for believing that ponderable matter consists. The undulatory theory of light was greatly promoted in the first instance by the known phenomena of sound; but the latter failed to show a counterpart to the phenomena of polarization and double refraction. These phenomena are only intelligible according to the theory of undulations by supposing the vibrations of the ether differ

altogether in character from the vibrations of the air which belong to sound. Hence the ether is not at all like air, and almost the only other thing known about it is that it has not been proved to possess any viscosity, and that the extremely tenuous matter of which the tails of comets is composed does not suffer any noticeable resistance in passing through the space which it is presumed to fill.—*Journal of Gaslighting.*

THE PROGRESS OF SCIENTIFIC KNOWLEDGE.[1]

By Lord KELVIN.

NOT the least important of the scientific events of the year is the publication, in the original German and in an English translation by Prof. De Jones, of a collection of Hertz's papers describing the researches by which he was led up to the experimental demonstration of magnetic waves. For this work the Rumford medal of the Royal Society was delivered to Prof. Hertz three years ago by my predecessor, Sir George Stokes. To fully appreciate the book now given to the world, we must carry our minds back to the early days of the Royal Society, when Newton's ideas regarding the forces which he saw to be implied in Kepler's laws of the motions of the planets and of the moon were frequent subjects of discussion at its regular meetings, and at perhaps even more important nonofficial conferences among its Fellows.

In 1684 the senior secretary of the Royal Society, Dr. Halley, went to Cambridge to consult Mr. Newton on the subject of the production of the elliptic motion of the planets by a central force,[2] and on December 10 of that year he announced to the Royal Society that he "had seen Mr. Newton's book, 'De Motu Corporum.'" Some time later, Halley was requested to "remind Mr. Newton of his promise to enter an account of his discoveries in the register of the Society," with the result that the great work "Philosophiæ Naturalis Principia Mathematica" was dedicated to the Royal Society, was actually presented in manuscript, and was communicated at an ordinary meeting of the Society on April 28, 1686, by Dr. Vincent. In acknowledgment, it was ordered that "a letter of thanks be written to Mr. Newton, and that the printing of his book be referred to the consideration of the council; and that in the meantime the book be put into the hands of Mr. Halley, to make a report thereof to the council." On May 19 following, the Society resolved that "Mr. Newton's 'Philosophiæ Naturalis Principia Mathematica' be printed forthwith in quarto, in a fair letter; and that a letter be written to him to signify the Society's resolution, and to desire his opinion as to the volume, cuts, etc." An exceedingly interesting letter was accordingly written to Newton by Halley, dated London, May 22, 1686, which we find printed in full in Weld's "History of the Royal Society" (vol. i., pp. 308-309). But the council knew more than the Royal Society at large of its power to do what it wished to do. Biology was much to the front then, as now, and the publication of Willughby's book, "De Historia Piscium," had exhausted the Society's finances to such an extent that the salaries even of its officers were in arrears. Accordingly, at the council meeting of June 2, it was ordered that "Mr. Newton's book be printed, and that Mr. Halley undertake the business of looking after it, and printing it at his own charge, which he engaged to do."

It seems that at that time the office of treasurer must have been in abeyance; but with such a senior secretary as Dr. Halley there was no need for a treasurer.

Halley, having accepted copies of Willughby's book, which had been offered to him in lieu of payment of arrears of salary[3] due to him, cheerfully undertook the printing of the "Principia" at his own expense, and entered instantly on the duty of editing it with admirable zeal and energy, involving, as it did, expostulations, arguments, and entreaties to Newton not to cut out large parts of the work, which he wished to suppress[4] as being too slight and popular, and as being possibly liable to provoke questions of priority. It was well said by Rigaud, in his "Essay on the first publication of the Principia," that "under the circumstances it is hardly possible to form a sufficient estimate of the immense obligation which the world owes in this respect to Halley, without whose great zeal, able management, unwearied perseverance, scientific attainments, and disinterested generosity the 'Principia' might never have been published."[5] Those who know how much worse than "law's delays" are the troubles, cares and labor involved in bringing through the press a book on any scientific subject at the present day will admire Halley's success in getting the "Principia" published within about a year after the task was committed to him by the Royal Society two hundred years ago.

When Newton's theory of universal gravitation was thus made known to the world, Descartes' *Vortices*, an invention supposed to be a considerable improvement on the older invention of crystal cycles and epi-cycles from which it was evolved, was generally accepted, and seems to have been regarded as quite satisfactory by nearly all the philosophers of the day.

The idea that the sun pulls Jupiter, and Jupiter pulls back against the sun with equal force, and that the sun, earth, moon, and planets all act on one another with mutual attractions, seemed to violate the supposed philosophic principle that matter cannot act where it is not. Descartes' doctrine died hard among the mathematicians and philosophers of continental Europe; and for the first quarter of last century belief in universal gravitation was an insularity of our countrymen.

Voltaire, during a visit which he made to England in 1727, wrote: "A Frenchman who arrives in London finds a great alteration in philosophy as in other things. He left the world full; he finds it empty. At Paris you see the universe composed of vortices of subtile matter; at London we see nothing of the kind. With you it is the pressure of the moon which causes the tides of the sea; in England it is the sea which gravitates toward the moon. . . . You will observe also that the sun, which in France has nothing to do with the business, here comes in for a quarter of it. Among you Cartesians all is done by impulsion; with the Newtonians it is done by an attraction of which we know the cause no better."[1] Indeed, the Newtonian opinions had scarcely any disciples in France until Voltaire asserted their claims on his return from England in 1728. Till then, as he himself says, there were not twenty Newtonians out of England.[2]

In the second quarter of the century sentiment and opinion in France, Germany, Switzerland, and Italy experienced a great change. "The mathematical prize questions proposed by the French Academy naturally brought the two sets of opinions into conflict." A Cartesian memoir of John Bernoulli was the one which gained the prize in 1730. It not infrequently happened that the Academy, as if desirous to show its impartiality, divided the prize between Cartesians and Newtonians. Thus in 1734, the question being the cause of the inclination of the orbits of the planets, the prize was shared between John Bernoulli, whose memoir was founded on the system of vortices, and his son Daniel, who was a Newtonian. The last act of homage of this kind to the Cartesian system was performed in 1740, when the prize on the question of the tides was distributed between Daniel Bernoulli, Euler, Maclaurin, and Cavallieri; the last of whom had tried to amend and patch up the Cartesian hypothesis on this subject.[3]

On February 4, 1744, Daniel Bernoulli wrote as follows to Euler: "Uebrigens glaube ich, dass der Aether sowohl *gravis versus solem*, vis die Luft versus terram sey, und kann Ihnen night bergen, dass ich über diese Puncte ein völliger Newtonianer bin, vnd verwundere ich mich, dass sie den Principiis Cartesianis so lang adhäriren; es möchte wohl einige Passion vielleicht mit unterlaufen. Hat Gott können eine *animam*, deren Natur uns unbegreiflich ist, erchaffen, so hat er auch können eine attractionem universalem materiæ imprimiren, wen gleich solche attractio *supra captum* ist, da hingegen die Principia Cartesiana allzeit *contra captum* etwas involviren."

Here the writer, expressing wonder that Euler had so long adhered to the Cartesian principles, declares himself a thorough-going Newtonian, not merely in respect to gravitation *versus* vortices, but in believing that matter may have been created simply with the law of universal attraction without the aid of any gravific medium or mechanism. But in this he was more Newtonian than Newton himself.

Indeed, Newton was not a Newtonian, according to Daniel Bernoulli's idea of Newtonianism, for in his letter to Bentley of date February 25, 1792,[4] he wrote: "That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it." Thus Newton in giving out his great law did not abandon the idea that matter cannot act where it is not. In respect, however, of merely philosophic thought, we must feel that Daniel Bernoulli was right; we can conceive the sun attracting Jupiter, and Jupiter attracting the sun, without any intermediate medium, if they are ordered to do so. But the question remains, Are they so ordered? Nevertheless, I believe all, or nearly all, his scientific contemporaries agreed with Daniel Bernoulli in answering this question affirmatively. Very soon after the middle of the eighteenth century Father Boscovich[5] gave his brilliant doctrine (if infinitely improbable theory) that elastic rigidity of solids, the elasticity of compressible liquids and gases, the attractions of chemical affinity and cohesion, the forces of electricity and magnetism—in short, all the properties of matter except heat, which he attributed to a sulphurous fermenting essence—are to be explained by mutual attractions and repulsions, varying solely with distances, between mathematical points endowed also, each of them, with inertia. Before the end of the eighteenth century the idea of action-at-a-distance through absolute vacuum had become so firmly established, and Boscovich's theory so unqualifiedly accepted as a reality, that the idea of gravitational force or electric force or magnetic force being propagated through and by a medium seemed as wild to the naturalists and mathematicians of one hundred years ago as action-at-a-distance had seemed to Newton and his contemporaries one hundred years earlier. But a retrogression from the eighteenth century school of science set in early in the nineteenth century.

Faraday, with his curved lines of electric force, and his dielectric efficiency of air and of liquid and solid insulators, resuscitated the idea of a medium through which, and not only through which but *by* which, forces of attraction or repulsion, seemingly acting at a distance, are transmitted. The long struggle of the first half of the eighteenth century was not merely on the question of a medium to serve for gravific mechanism, but on the correctness of the Newtonian law of gravitation as a matter of fact however explained. The corresponding controversy in the nineteenth century was very short, and it soon became obvious that Faraday's idea of the transmission of electric force by a medium not only did not violate Coulomb's law of relation between force and distance, but that, if real, it must give a thorough explanation of that law.[1] Nevertheless, after Faraday's discovery[2] of the different specific inductive capacities of different insulators, twenty years passed before it was generally accepted in continental Europe. But before his death, in 1867, he had succeeded in inspiring the rising generation of the scientific world with something approaching to faith that electric force is transmitted by a medium called ether, of which, as had been believed by the whole scientific world for forty years, light and radiant heat are transverse vibrations. Faraday himself did not rest with this theory for electricity alone. The very last time I saw him at work in the Royal Institution was in an underground cellar, which he had chosen for freedom from disturbance; and he was arranging experiments to test the time of propagation of magnetic force from an induction coil through a distance of many yards to a fine steel needle polished to reflect light; but no result came from those experiments. About the same time, or soon after, certainly not long before the end of his working time, he was engaged (I believe at the shot tower near Waterloo Bridge on the Surrey side) in efforts to discover relations between gravity and magnetism, which led also to no result.

Absolutely nothing has hitherto been done for gravity either by experiment or observation toward deciding between Newton and Bernoulli as to the question of its propagation through a medium, and up to the present time we have no light, even so much as to point a way for investigation, in that direction. But for electricity and magnetism, Faraday's anticipations and Clerk Maxwell's splendidly developed theory have been established on the sure basis of experiment by Hertz's work, of which his own most interesting account is this year presented to the world in the German and English volumes to which I have referred. It is interesting to know, as Hertz explains in his introduction, and is very important in respect to the experimental demonstration of magnetic waves to which he was led, that he began his electric researches in a problem happily put before him thirteen years ago by Prof. von Helmholtz, of which the object was to find by experiment some relation between electromagnetic forces and dielectric polarization of insulators, without in the first place any idea of discovering a progressive propagation of those forces through space.

It was by sheer perseverance in philosophical experimenting that Hertz was led to discover a finite velocity of propagation of electromagnetic action, and then to pass on to electromagnetic waves in air and their reflection, and to be able to say, as he says in a short reviewing sentence at the end of his eighth paper: "Certainly it is a fascinating idea that the processes in air which we have been investigating, represent to us on a million fold larger scale the same processes which go on in the neighborhood of a Fresnel mirror, or between the glass plates used for exhibiting Newton's rings."

Prof. Oliver Lodge has done well in connection with Hertz's work to call attention[3] to old experiments, and ideas taken from them, by Joseph Henry, which came more nearly to an experimental demonstration of electromagnetic waves than anything that had been done previously. Indeed, Henry, after describing experiments showing powerful enough induction due to a single spark from the prime conductor of an electric machine to magnetize steel needles at a distance of thirty feet in a cellar beneath with two floors and ceilings intervening, says that he is "disposed to adopt the hypothesis of an electrical plenum," and concludes with a short reviewing sentence: "It may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from a flint and steel in the case of light."

Prof. Oliver Lodge himself did admirable work in investigations with reference to lightning rods,[4] coming very near to experimental demonstrations of electromagnetic waves; and he drew important lessons regarding "electrical surgings" in an insulated bar of metal "induced by Maxwell's and Heavisides' electromagnetic waves," and many other corresponding phenomena manifested both in ingenious and excellent experiments devised by himself and in natural effects of lightning.

Of electrical surgings or waves in a short insulated wire, and of interference between ordinary and reflected waves, and positive electricity appearing where negative might have been expected, we hear first, it seems, in Herr von Bezold's "Researches on the Electric Discharge" (1870), which Hertz gives as the third paper of his collection, with interesting and ample recognition of its importance in relation to his own work.

In connection with the practical development of magnetic waves, you will, I am sure, be pleased if I call your attention to two papers by Prof. G. F. Fitzgerald, which I heard myself at the meeting of the British Association at Southport in 1883. One of them is entitled "On a Method of Producing Electromagnetic Disturbances of comparatively Short Wave Lengths." The paper itself is not long, and I shall read it to you in full, from the "Report of the British Association," 1883: "This is by utilizing the alternating currents produced when an accumulator is discharged through a small resistance. It is possible to produce waves of as little as two meters wave length, or even less." This was a brilliant and useful suggestion. Hertz, not knowing of it, used the method; and, making as little as possible of the "accumulator," got waves of as little as 10 cm. wave length in many of his fundamental experiments. The title alone of Fitzgerald's other paper, "On the Energy Lost by Radiation from Alternating Currents," is in itself a valuable lesson in the electro-magnetic theory of light, or the undulatory theory of magnetic disturbance. It is interesting to compare it with the title of Hertz's eleventh paper, "Electric Radiation;" but I cannot refer to this paper without express-

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[1] Abstract from the presidential address before the Royal Society, Nov. 30, 1893.

[2] Whewell's "History of the Inductive Sciences," vol. ii. p. 77.

[3] It is recorded in the Minutes of Council that the arrears of salary due to Hooke and Halley were resolved to be paid by copies of Willughby's work. Halley appears to have assented to this unusual proposition, but Hooke wisely "desired six months' time to consider of the acceptance of such payment."

The publication of the "Historia Piscium," in an edition of 500 copies, cost the Society £400. It is worthy of remark, as illustrative of the small sale which scientific books met with in England at this period, that a considerable time after the publication of Willughby's work, Halley was ordered by the Council to endeavor to effect a sale of several copies with a bookseller at Amsterdam, as appears in a letter from Halley requesting Boyle, then at Rotterdam, to do all in his power to give publicity to the book. When the Society resolved on Halley's undertaking to measure a degree of the earth, it was voted that "he be given £50 or fifty 'Books of Fishes.'" (Weld's "History of the Royal Society," vol. i. p. 310.)

[4] "The third [book] I now design to suppress. Philosophy is such an impertinently litigious lady that a man had as good be engaged in lawsuits as have to do with her. I found it so formerly, and I am now no sooner come near her again but she gives me warning. The first two books without the third will not so well bear the title of 'Philosophiæ Naturalis Principia Mathematica,' and therefore I have altered it to this, 'De Motu Corporum Libri duo'; but, upon second thoughts, I retain the former title. 'Twill help the sale of the book, which I ought not to diminish now 'tis yours." (*Ibid.*, p. 311.)

[5] *Ibid.*, p. 310.

[1] Whewell's "History of the Inductive Sciences," vol. ii. pp. 202-203.

[2] *Ibid.*, vol. ii. p. 201.

[3] *Ibid.*, vol. ii. pp. 198, 199.

[4] "The Correspondence of Richard Bentley, D.D.," vol. i. p. 70.

[5] "Theoria Philosophiæ Naturalis redacta ad unicam legem virium in natura existentium auctore P. Rogerio Josepho Boscovich, Societatis Jesu," 1st edition, Vienna, 1758: 2d edition, amended and extended by the author, Venice, 1763.

[1] "Electrostatics and Magnetism," Sir W. Thomson, Arts. I. (1842) and II. (1845), particularly § 25 of Art. II.

[2] 1837, "Experimental Researches," 1161-1306.

[3] "Modern Views of Electricity," pp. 369-372.

[4] "Lightning Conductors and Lightning Guards," Oliver J. Lodge, F.R.S. Whittaker & Co.

ing the admiration and delight with which I see the words "rectilinear propagation," "polarization," "reflection," "refraction," appearing in it as subtitles.

During the fifty-six years which have passed since Faraday first offended physical mathematicians with his curved lines of force, many workers and many thinkers have helped to build up the nineteenth century school of *plenum*; one ether for light, heat, electricity, magnetism; and the German and English volumes containing Hertz's electrical papers, given to the world in the last decade of the century, will be a permanent monument of the splendid consummation now realized.

But, splendid as this consummation is, we must not fold our hands and think or say there are no more worlds to conquer for electrical science. We do know something now of magnetic waves. We know that they exist in nature, and that they are in perfect accord with Maxwell's beautiful theory. But this theory teaches us nothing of the actual motions of matter constituting a magnetic wave. Some definite motion of matter perpendicular to the lines of alternating magnetic force in the waves and to the direction of propagation of the action through space, there must be; and it seems almost satisfactory as a hypothesis to suppose that it is chiefly a motion of ether with a comparatively small but not inconsiderable loading by fringes of ponderable molecules carried with it. This makes Maxwell's "electric displacement" simply a to and fro motion of ether across the line of propagation, that is to say, precisely the vibrations in the undulatory theory of light according to Fresnel. But we have as yet absolutely no guidance toward any understanding or imagining of the relation between this simple and definite alternating motion, or any other motion or displacement of the ether, and the earliest known phenomena of electricity and magnetism—the electrification of matter, and the attractions and repulsions of electrified bodies; the permanent magnetism of lodestone or steel, and the attractions and repulsions due to it; and certainly we are quite as far from the clew to explaining by ether or otherwise, the enormously greater forces of attraction and repulsion now so well known after the modern discovery of electromagnetism.

Fifty years ago it became strongly impressed on my mind that the difference of quality between vitreous and resinous electricity, conventionally called positive and negative, essentially ignored as it is in the mathematical theories of electricity and magnetism with which I was then much occupied (and in the whole science of magnetic waves as we have it now), must be studied if we are to learn anything of the nature of electricity and its place among the properties of matter. This distinction, essential and fundamental as it is in frictional electricity, electro-chemistry, thermo-electricity, pyro-electricity of crystals and piezo-electricity of crystals, had been long observed in the old known beautiful appearances of electric glow and brushes and sparks from points and corners on the conductors of ordinary electric machines and in exhaustive receivers of air pumps with electricity passed through them. It was also known probably as many as fifty years ago, in the vast difference of behavior of the positive and negative electrodes of the electric arc lamp. Faraday gave great attention to it[1] in experiments and observations regarding electric sparks, glows, and brushes, and particularly in his "dark discharge" and "dark space" in the neighborhood of the negative electrode in partial vacuum. In [1523] of his twelfth series, he says: "The results connected with the different conditions of positive and negative discharge will have a far greater influence on the philosophy of electrical science than we at present imagine." His "dark discharge" ([1544–1554]) through space around or in front of the negative electrode was a first installment of modern knowledge in that splendid field of experimental research which, fifteen years later, and up to the present time, has been so fruitfully cultivated by many of the able scientific experimenters of all countries.

The Royal Society's Transactions and Proceedings of the last years contain, in the communications of Gassiot,[2] Andrews and Tait,[3] Cromwell Varley,[4] De la Rue and Muller,[5] Spottiswoode,[6] Moultan,[7] Plucker,[8] Crookes,[9] Grove,[10] Robinson,[11] Schuster,[12] J. J. Thomson,[13] and Fleming,[14] almost a complete history of the new province of electrical science which has grown up largely in virtue of the great modern improvements in practical methods for exhausting air from glass vessels, by which we now have "vacuum tubes" and bulbs containing less than 1/100,000 of the air which would be left in them by all that could be done in the way of exhausting (supposed to be down to 1 mm. of mercury) by the best air pump of fifty years ago. A large part of the fresh discoveries in this province have been made by the authors of these communications, and their references to the discoveries of other workers very nearly complete the history of all that has been done in the way of investigating the transmission of electricity through highly rarefied air and gases since the time of Faraday.

Varley's short paper of 1871, which, strange to say, has lain almost or quite unperceived in the Proceedings during the twenty-two years since its publication,

[1] "Experimental Researches," Series 12 and 13, January and February, 1838.

[2] Roy. Soc. Proc., vol. 10, 1860, pp. 36, 309, 274, 488.

[3] Roy. Soc. Proc., vol. 10, 1860, p. 274; Phil. Trans.

[4] Roy. Soc. Proc., vol. 19, 1871, p. 236.

[5] Roy. Soc. Proc., vol. 23, 1875, p. 356; vol. 26, 1877, p. 519; vol. 27, 1878, p. 374; vol. 29, 1879, p. 281; vol. 35, 1883, p. 292; vol. 36, 1884, pp. 151, 206; Phil. Trans., 1878, pp. 55, 155; 1880, p. 65; 1883, 477.

[6] Roy. Soc. Proc., vol. 23, 1875, pp. 356, 455; vol. 25, 1876, pp. 73, 547; vol. 25, 1877, pp. 93, 303; vol. 27, 1878, p. 60; vol. 28, 1879, p. 31; vol. 30, 1880, p. 302; vol. 32, 1881, pp. 385, 398; vol. 33, 1882, p. 449; Phil. Trans., 1876, pp. 163, 210; 1879, 165; 1880, p. 593.

[7] Roy. Soc. Proc., vol. 28, 1879, p. 91; vol. 30, 1880, p. 309; vol. 32, 1881, pp. 380, 392; vol. 33, 1882, p. 453; Phil. Trans., 1879, p. 165; 1880, p. 593.

[8] Roy. Soc. Proc., vol. 10, 1860, p. 256.

[9] Roy. Soc. Proc., vol. 28, 1879, pp. 347, 477; Phil. Trans., 1878, p. 641; 1880, p. 135; 1881, 327.

[10] Roy. Soc. Proc., vol. 28, 1879, p. 181.

[11] Roy. Soc. Proc., vol. 12, 1863, p. 202.

[12] Roy. Soc. Proc., vol. 37, 1884, pp. 78, 317; vol. 42, 1887, p. 371; vol. 47, 1890, pp. 300, 308.

[13] Roy. Soc. Proc., vol. 42, 1887, p. 340; vol. 49, 1891, p. 94.

[14] Roy. Soc. Proc., vol. 47, 1890, p. 118.

contains an admirable first installment of discovery in a new field—the molecular torrent from the "negative pole," the control of its course by a magnet, its pressure against either end of a pivoted vane of mica according as it is directed by a magnet to one end or the other, the shadow produced by its interception by a mica screen. Quite independently of Varley, and not knowing what he had done, Crookes was led to the same primary discovery, not by accident, and not merely by experimental skill and acuteness of observation. He was led to it by carefully designed investigation, starting with an examination of the causes of irregularities which had troubled[1] him in his weighing of thallium; and, going on to trials for improving Cavendish's gravitational measurement, in the course of which he discovered that the seeming attraction by heat is only found in air of greater than 1/1,000[2] of ordinary density; and that there is repulsion increasing to a maximum when the density is decreased from 1/1,000 to 36/1,000,000, and thence diminishing toward zero as the rarefaction is farther extended to density 1/20,000,000. From this discovery Crookes came to his radiometer, first without and then with electrification, powerfully aided by Sir George Stokes.[3] As he went on he brought all his work more and more into touch with the kinetic theory of gases; so much so that when he discovered the molecular torrent he immediately gave it its true explanation—molecules of residual air, or gas, or vapor projected at great velocities[4] by electric repulsion from the negative electrode. This explanation has been repeatedly and strenuously attacked by many other able investigators, but Crookes has defended[5] it, and thoroughly established it by what I believe is irrefragable evidence of experiment. Skillful investigation perseveringly continued brought out more and more of wonderful and valuable results; the non-importance of the position of the positive electrode; the projection of the torrent *perpendicularly* from the surface of the negative electrode; its convergence to a focus and divergence thenceforward when the surface is slightly convex; the slight but perceptible repulsion between two parallel torrents due, according to Crookes, to negative electrification of their constituent molecules; the change of direction of the molecular torrent by a neighboring magnet; the tremendous heating effect of the torrent from a concave electrode when glass, metal, or any ponderable substance is placed in the focus; the phosphorescence produced on a plate coated with sensitive paint by a molecular torrent skirting along it; the brilliant colors—turquoise blue, emerald, orange, ruby red—with which gray colorless objects and clear colorless crystals glow on their struck faces when lying separately or piled up in a heap in the course of a molecular torrent; "electrical evaporation" of negatively electrified liquids and solids;[6] the seemingly red hot glow, but with no heat conducted inward from the surface, of cool, solid silver kept negatively electrified in a vacuum of 1/1,000,000 of an atmosphere, and thereby caused to rapidly evaporate. This last mentioned result is almost more surprising than the phosphorescent glow excited by molecular impacts in bodies not rendered perceptibly phosphorescent by light. Both phenomena will surely be found very telling in respect to the molecular constitution of matter and the origination of thermal radiation, whether visible as light or not. In the whole train of Crookes' investigations on the radiometer, the viscosity of gases at high exhaustions, and the electric phenomena of high vacuums, ether seems to have nothing to do except the humble function of showing to our eyes something of what the atoms and molecules are doing. The same confession of ignorance must be made with reference to the subject dealt with in the important researches of Schuster and J. J. Thomson on the passage of electricity through gases. Even in Thomson's beautiful experiments showing currents produced by circuital electromagnetic induction in complete poleless circuits, the presence of molecules of residual gas or vapor seems to be *the essential*. It seems certainly true that without the molecules there could be no current, and that without the molecules electricity has no meaning. But in obedience to logic I must withdraw one expression I have used. We must not imagine that "presence of molecules is *the* essential." It is certainly *an* essential. Ether also is certainly *an* essential, and certainly has more to do than merely to telegraph to our eyes to tell us of what the molecules and atoms are about. If a first step toward understanding the relations between ether and ponderable matter is to be made, it seems to me that the most hopeful foundation for it is knowledge derived from experiment on electricity in high vacuum; and if, as I believe is true, there is good reason for hoping to see this step made, we owe a debt of gratitude to the able and persevering workers of the last forty years who have given us the knowledge we have; and we may hope for more and more from some of themselves and from others encouraged by the fruitfulness of their labors to persevere in the work.

The president then presented the medals awarded by the society as follows: The Copley medal to Sir George Gabriel Stokes, Bart., F.R.S., for his researches and discoveries in physical science; a Royal medal to Prof. A. Schuster, F.R.S., for his spectroscopic inquiries, and his researches on disruptive discharge through gases and on terrestrial magnetism; a Royal medal to Prof. H. Marshall Ward, F.R.S., for his researches into the life history of fungi and schizomycetes; and the Davy medal to Prof. J. H. Van't Hoff and Dr. J. A. Le Bel, in recognition of their introduction of the theory of asymmetric carbon, and its use in explaining the constitution of optically active carbon compounds.

THE corner stone of an engineering college for the University of Illinois, to cost $160,000, was laid at Champaign on December 13. Prof. Thurston, of Cornell University, delivered the principal address.

[1] Tribulation, not undisturbed progress, gives life and soul, and leads to success when success can be reached, in the struggle for natural knowledge.

[2] Crookes, "On the Viscosity of Gases at High Exhaustions," § 625, Phil. Trans., February, 1881, p. 403.

[3] Phil. Trans. vol. 172 (1882), pp. 387, 435.

[4] Probably, I believe, not greater in any case than two or three kilometers per second.

[5] Address to the Institute of Telegraphic Engineers, 1891.

[6] Roy. Soc. Proc., June 11, 1891.

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